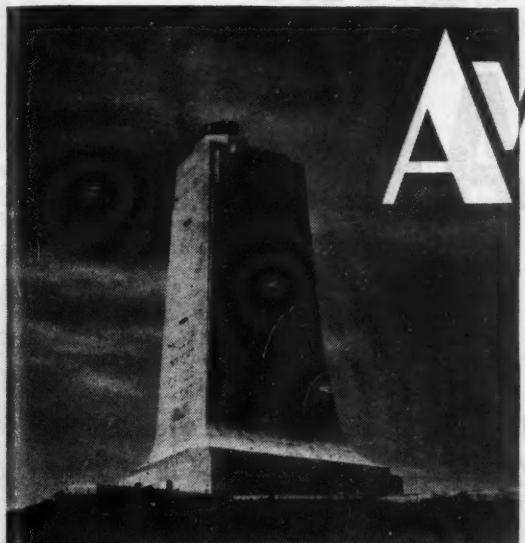

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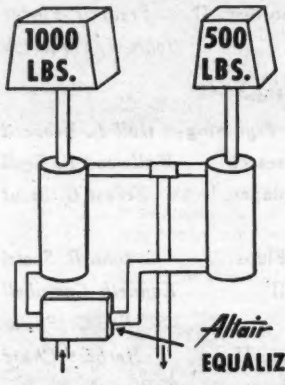
Altair HYDRAULIC

FLOW-EQUALIZER

Revolutionary development meters fluid in either direction



Irrespective of wide differentials in loads or rate of flow the Altair Equalizer synchronizes the action in *both* directions. Although the cylinder on the left is doing twice the work of the other – both cylinders travel at the same speed during their entire strokes.

Here – for the first time – hydraulic fluid is accurately metered in either direction from one line into two branch lines. Differentials in restriction, loads or friction are compensated for, even in pronounced unbalanced conditions.

The installation is unique. It is only necessary to install the Altair Flow Equalizer in place of the "T" in the pressure *or* return line to accomplish full synchronization of the hydraulic actuating cylinders or motors.

The Altair Flow Equalizer incorporates a balanced metering piston, and does not depend on outside mechanical action as the proportioning agent. An exclusive variable orifice controls equalization over a wide range of flows – the ½" tube size shown handles flows of from 2 GPM to 8 GPM. The unit weighs only 2.5 pounds.

This Equalizer has many applications. It has already been specified on five airplanes to equalize wing flaps, bomb doors, cargo doors and landing gear. Our engineering department is available to assist in working out other applications with you. Write for complete data. Pacific Division, Bendix Aviation Corporation, North Hollywood, California. Sales Engineering Offices in New York City and Dayton.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

Briefing for August

When, in May, we inaugurated our new marketing section with "Here Are Your Markets" we pointed out that "merchandising its products has always been one of the toughest and, in many cases, most sorely neglected problems faced by the aircraft industry." Proof of that statement—if such were needed—has already been forthcoming, for in "Where Are Those Marketing Plans?" (page 121) Dr. John Frederick presents the sad case history of a man who wants to be a distributor but can't find out what the requirements are. It is a real challenge to the industry—one we hope won't go unanswered.

Airbrush artists and Sunday supplement writers are still trying to give the impression that flying a helicopter is as simple as driving a car; and they are thereby doing the industry a disservice. Just exactly why is told on page 116 by "Les" Morris, Sikorsky company copter pioneer. And if anyone should know, it's Les—for he was one of the first up-and-down craft flying instructors.

You who design, build, operate, and maintain our aircraft seem to have an insatiable appetite for AVIATION'S design analyses. It's a real pleasure to try and satisfy it, though, especially when we come up with such a grand job as Hall Hibbard, Lockheed's v.-p. and chief engineer, has done this month for No. 8 in our series—on the P-38 *Lightning,* one of the most controversial and successful fighters ever built. (Page 123.)

Things that are simple in principle can often be more than rough on engineers and predicting takeoff performance of seaplanes is a good case in point. Ernie Stout of Convair long ago found that out the hard way and, drawing on long experience, he's put the job on a sound basis that's going to save a lot of engineers a lot of headaches. An outstanding writing job, this new series on take off analysis begins on page 150.

There's even more in the design and production field, though, for this month we present concluding installments of Kenneth Campbell's thorough-going study of fan cooling (page 156); Herbert Chase's analysis of time- and money-saving hole piercing technique (page 161); and William Findley's detailed study on load carrying characteristics of cellulose acetate plastic (page 163).

With operating costs always on the front line of every transport operator's perennial battle for survival, the old question of what equipment to use will always be of prime importance. Continuing his important series on "The Economic Future of Aviation Technology" (page 118) Frederic Flader this month gives clues to the answers in his analysis of operating expenses of three different types of aircraft, with economic trends projected and estimated beyond the transition period which will follow the war.

B. M. Compton, veteran aviation instructor and now Director of Aviation for Ogden, Utah, schools, who presents an improved graphic method of avigation, a well-illustrated article to be found on page 186.

Sales and traffic departments may question every pound of the flight engineer's weight, but to operations he's often worth more than that weight in gold. On page 184 we present the first comprehensive story dealing with the development of this new profession, a story which also shows just how the flight engineer's influence can reach clear back to the design boards to get better airplanes.

A fixed base operator's success has been said to consist of equal parts of hard labor and ingenuity. Bob Shank, one of the real veterans of the aviation industry, has more than his share of ingenuity, as you'll see in the raft of helpful hints offered in the article titled "At Hoosier Airport They *Like* Problems." It begins on page 170.

Both personal plane owners and fixed base operators will find a lot of help, too, in the step-by-step article covering installation and servicing of wooden propellers. It's on page 174.

And for those who maintain planes of any and all sizes using Aerols, Assistant Editor Thorp has written a detailed method of procedure for proper servicing of these vital units (page 167).

Contract terminations have finally become a reality—and you'd think, judging by the action of aviation stocks, that this was a great big surprise. But if you'll observe the manufacturers, you'll see that our industry is taking cutbacks and terminations in stride. The "why" of this relative calmness is explained by Financial Editor Hoadley on page 206. Discounting the stock's action, he gives the investor a realistic picture of the situation as it actually is.

Down the Years in AVIATION'S Log

25 Yr. Ago (1919)—AVIATION celebrates third anniversary . . . Washington-New York airmail route carries 15,643 lb. mail in month . . . Cleveland-Chicago airmail route completes 75th consecutive non-stop flight without accident or delay . . . British dirigible R-34 flies from Scotland to New York in 4½ days and returns in 3¼ days . . . Navy starts two airship hangars 800 by 250 and 200 ft. high . . . Appropriation made for $2,500,000 British-built dirigible for Navy . . . Aeronautical Peace Conference lays down first world flying rules.

15 Yr. Ago (1929)—German liner *Bremen* catapults Heinkel K2 seaplane from deck while at sea to expedite mail to shore . . . Jackson and O'Brine fly Curtiss *St. Louis Robin* for 17½ days without landing, using 3,300 gal. gasoline picked up in 44 refueling contacts . . . Army takes delivery of 40 Douglas observation planes and orders 20 more . . . Chicago disturbed by many local deaths from unlicensed plane crashes . . . P & W signs contract for new $2,000,000 Hartford plant . . . Guggenheim $150,000 safe airplane contest draws 16 entries . . . Southern Air Transport employs girl pilot as sales representative . . . Airmail plane drops four sacks on deck of *Leviathan* at sea . . . Boeing system completes 6,000,000th mile on Chicago-San Francisco-Seattle routes . . . Flying service inaugurated between New York City and Saratoga and Lake George . . . Chicago Municipal Airport handles 1,429 arrivals and 1,452 departures in week.

10 Yr. Ago (1934) — PAA's new Sikorsky S-42 *Brazilian Clipper* flying boat takes off in 18 sec. with 17 tons, climbs above 15,000 ft. in 47 min . . . Fog precipitation apparatus successfully demonstrated at Round Hill, Mass . . . General Foulois presents plan for purchase of 1,000 planes in 1934 . . . Westbound airmail averages 42 hr. 32 min., while eastbound takes 2 hr. less . . . Transcontinenal Air Transport erects fence at Columbus, Ohio, to control crowds . . . Stout starts Detroit-Cleveland-Buffalo service with Dornier flying boat.

THE HEART of many instruments that measure minute differentials of air pressure is the aneroid diaphragm. In the use of these diaphragms for the sensitive indication of pressures for aircraft flight and engine control, Kollsman Engineers have developed them to an extraordinary degree of reliability and precision. In the Kollsman Sensitive Altimeter, for instance, a reliable indication of 20 feet of altitude is achieved by a positive diaphragm movement of only .000053 inches at 50,000 feet. Further, this diaphragm is so formed that the logarithmic curve of pressure is translated into an even indication.

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Realism and the Personal Plane Market

TWENTY-FIVE HUNDRED YEARS have passed since Ezekiel's biblical vision of the living creatures lifted off the earth with their wings and wheels. But the combination of wings and wheels has not yet exceeded the utility for personal transportation of those vehicles having wheels alone. Until the utility of the airplane reaches or exceeds that of the automobile it is folly to make quantitative comparisons between their two markets.

This may seem obvious to many of us, yet it was not sufficiently apparent to enough of us in 1929 when men wise enough to know better planned civilian plane manufacturing schedules far in excess of the realistic market. This mistake must not be made again.

The plain truth is that we must stop looking at the personal airplane as something that will replace the automobile as the family vehicle. We must consider it as something that will supplement personal ground transportation at least until technical progress changes the nature of the air vehicle to increase its utility.

That leaves us with two markets: (1) the families with incomes sufficiently high to own and maintain two cars, or one car and some other vehicle used principally for pleasure, (2) the persons who will make their airplanes pay for themselves in full, or in part, by using them in some form of business.

Both of these markets are limited by the economic environment in which they develop. If the nation becomes engulfed in a great depression there will be little demand for personal plane or aviation services. If our postwar economy is successfully bolstered there will be healthy markets in both categories. We must base our postwar thinking on the latter possibility because the best laid plans would be of little use in economic chaos.

REGULATION OF CIVILIAN FLYING must be reduced, rather than increased or made complex by duplication and superimposition of state upon federal laws. Personal flying cannot be expected to increase substantially until the regulations controlling it approach the simplicity of those governing the use of automobiles or motor boats. There are recent encouraging symptoms of much greater unanimity of thought among the personal plane owners themselves about the degree of regulation necessary for their activities. This will be welcome to those who are charged with making the regulations.

Although quantitative comparisons of automotive and aircraft markets are illogical, we may, nevertheless, draw qualitatively upon automotive and other consumer merchandising practices. In fact we must if we are to be successful in aircraft distribution.

One of the most important elements is consumptuary credit. Automotive sales lagged until cars could be bought on time—and our brief prewar experience in airplane sales indicates the importance of this factor. But insurance companies and bankers must be realistic and work closely together, and with distributors and dealers, to reduce the cost of their services and to enable the sellers to receive their commissions promptly. If these steps are not taken, the way will be wide open for opportunists and unethical practitioners.

Manufacturers of accessories and parts must likewise streamline their activities to provide high quality equipment at low cost for non-military aircraft. If they do not, some other manufacturer will, because there will be a demand for these things from postwar pilots. When there is a demand for anything under the American system, somebody usually finds a way to provide it.

SALESMANSHIP is bound to have dulled somewhat during the lush years of government contracts for fixed base operators, hence it is time to sharpen this important distribution tool. We must not be satisfied with the prewar caliber of aviation salesmanship. We must learn more about the methods used in the established branches of consumer merchandising. The best of these methods must be adapted to the needs of our business and put into use. Much can be learned from automobile experience in maintenance and servicing of personal planes. Standardized service procedure and fixed charges for specific jobs are among the important fundamental principles.

Success in building the personal airplane market will be based broadly upon the ability of the industry to do three things—

1. Make the airplane more useful and easier to fly.
2. Make more people want to fly their own planes.
3. Make it easy for them to own, fly, and maintain their planes.

These are the foundation stones upon which the future business will be built.

Leslie E. Neville

EDITOR

Flying earlier model Sikorsky helicopter, author demonstrates precision control by spearing exact center of ring target mounted on pole. Temptations to say, "Just give me a helicopter and I'll do it, too," are discouraged—for this article clearly evidences fact that such 'copter piloting requires consummate skill.

Teaching the First Helicopter Pilots*

By C. L. "LES" MORRIS,
Sikorsky Aircraft Div. of United Aircraft Corp., Bridgeport, Conn.

In a 'copter, some conventional-plane tactics won't get you anywhere. But others—like putting your tail down for a landing—certainly will. For you'll abruptly take off backward! Just what else a "green" man is up against is lucidly revealed here by "Les" Morris, who pioneered the training at Wright Field.

IN THE INITIAL PAINSTAKING program to determine the capabilities and practicabilities of the Sikorsky XR-4 helicopter, pilot training was one of the major considerations—for pertinent use of these craft called for a full understanding of training factors and a consequent systematizing of the steps. Moreover, "pioneer" 'copter flyers were needed as a nucleus of the future program.

The scene was Wright Field, and the time was the summer of 1942. We had been busy at a tremendous number of jobs —nearly all of them deadlined "yesterday." The XR-4 had been put through comprehensive performance tests to find out just what it could do in the way of speed, load, climb, descent, altitude, etc.—for we had only had time to scratch the surface of these investigations prior to delivery of the craft.

Further, there had been preliminary operational trials, particularly bombing tests; also there were demonstrations to a multitude of persons, ranging from the Secretary of War, down through generals and other high-ranking officers, to official delegates from Allied countries. Our business was to prove in practice the engineering and structural integrity of the Sikorsky helicopter.

The demonstrations offered a preview of what would be required in the training program. For example, a wooden platform, 20-ft. square, was constructed 3 ft. off the ground so that simulated deck landings could be practiced. Of course, we could have used merely an outlined area on the ground so that missing the mark would have entailed no risks. But we felt it would be far more satisfactory to the pilot and more convincing to the onlookers to realize that an error might mean a crackup.

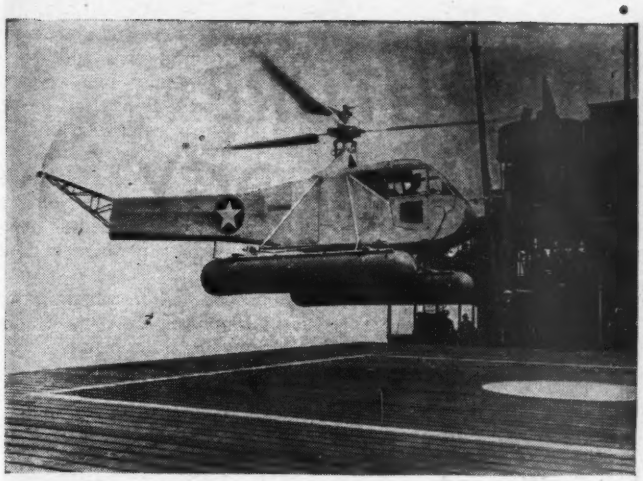
We made scores of successful landings on this "deck"; at any rate we made no *unsuccessful* ones. To simulate conditions surrounding flights into and out of small platforms on merchant vessels, we set up a 2-x-4 "mast," just beyond tip-reach of the rotor blades. Even this very practical hazard didn't alter the craft's ability to operate.

Prospective pilots watched our bombing projects with much interest. To begin with, the XR-4 had no bomb racks, so Col. H. Franklin Gregory took Col. Douglas M. Kilpatrick aloft with a 20-lb. dummy bomb on his lap. Gregory would hover 200 or 300 ft. high, then when he thought he was over the target he would poke Kilpatrick, who would heave the bomb overboard. I also took a turn at it, and we developed quite a competition to see which one could poke at the right time. We became reasonably accurate, but we were surprised to find how difficult it was to be sure we were looking straight down.

Kilpatrick was my first real student. I couldn't take credit for Gregory's training because he had soloed our VS-300 helicopter long before I even entered the picture; but Kilpatrick was an Army pilot with no rotary-wing experience, so I started with him from scratch. He was the guinea-pig on whom the present helicopter student training curriculum was painfully developed. He and I staggered hither and yon over Wright Field for hours—he, trying to make the craft do his bidding; I, trying to discover why he couldn't. His training brought to light most of the troubles that helicopter students must face, also the remedies for them. His limitless enthusiasm and his ability to smile in the face of adversity made him an excellent subject in this pioneering effort.

The first phase of the program was brief conversion to the helicopter's controls. The control stick was quite sensitive, and the tendency of all newcomers was to indulge in violent rocking, diving, and zooming for awhile. Frequently, I would have to take over and straighten things out a few times before the student

* From the manuscript of the author's forthcoming book, "Pioneering the Helicopter" (McGraw-Hill Book Co.).



Col. Gregory lands XR-4 on deck of Bunker Hill. For training and demonstrations, simulated deck was built earlier at Wright Field, with special mast made of 2-by-4's added as a realistic hazard.

Newest version of Sikorsky helicopter is this XR-6, two-place military model. It is to be produced for Materiel Command AAF by Nash-Kelvinator, which will fabricate the craft under license from Sikorsky.

began to get the knack of it. This was a common difficulty, so that the onlookers and the crew became quite expert at judging, from the ship's antics, just when the newcomer had the controls. In order to give plenty of freedom for error, this stage of training was carried on at 200 or 300-ft. altitude, and at moderate speeds.

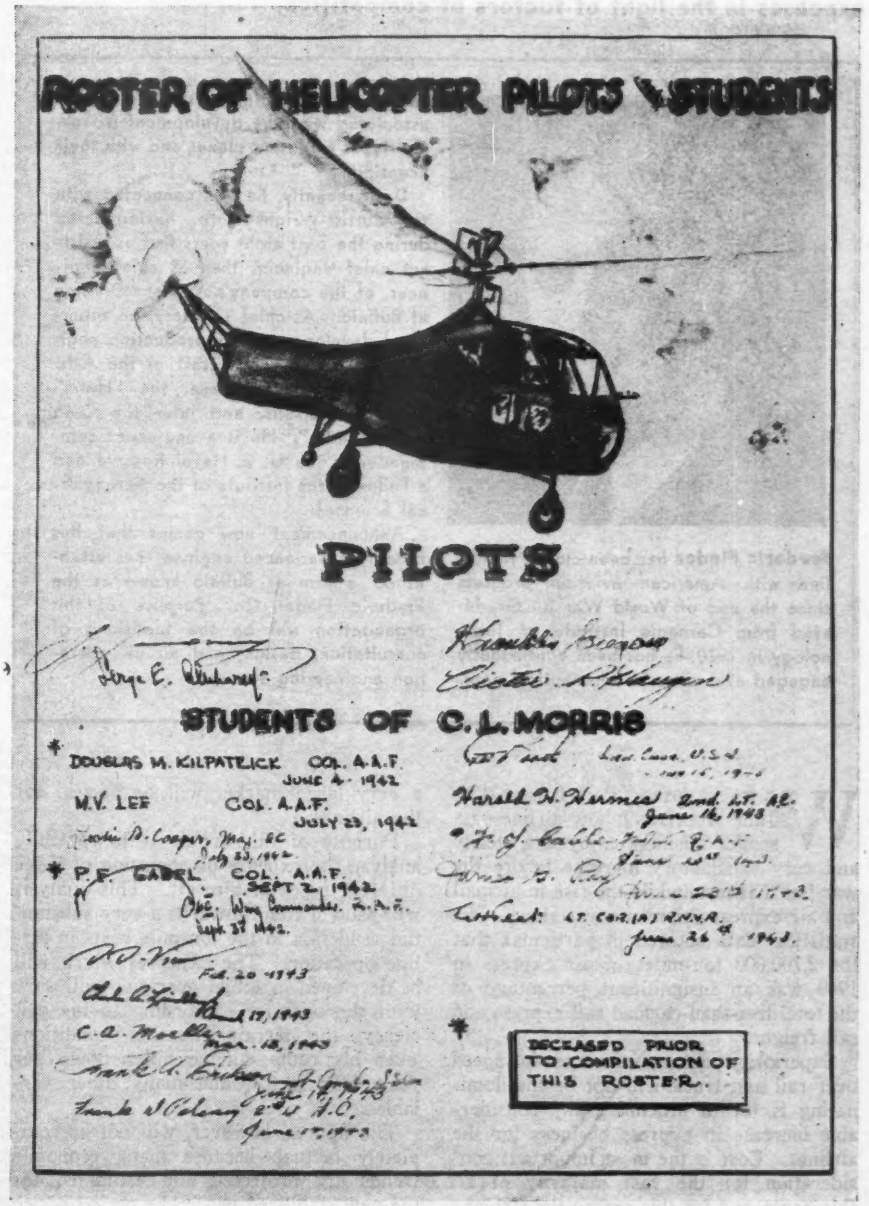
Kilpatrick was an excellent pilot, but he was no exception to the over-control rule. However, after 15 or 20 min. he could hold her steady or make smooth turns, so he was introduced to the next phase—pitch and throttle, on which I had spent so many arm-chair hours before I made the first flights. In the XR-4, this was a particularly vital operation—if wrongly manipulated it could well be fatal. Most rotary-wing aircraft have no braces, struts, or cables to hold the main rotor blades from folding up. The only thing that prevents this is an invisible power as strong as any husky cable—and far more reliable—namely, centrifugal force.

When you whirl a weight on a string, it is centrifugal force that makes it seemingly defy the laws of gravity, even to the point of being swung in a vertical path. The blades of a helicopter act similarly. In fact, Mr. Sikorsky once said, "If we could find a rope that would keep its shape, we could use it for our blades —provided it would have the decency not to wrap itself around someone's neck when we stopped the engine."

But the centrifugal force of a given weight depends upon the speed at which it turns. When you swing a weight on a string very slowly, it doesn't stand out very far. The same phenomenon is evidenced in helicopter rotor blades. If for some reason the blades should gradually slow down in flight, they would be held out with less and less force. They would therefore "cone" more and more, until ultimately they would fold up completely like an umbrella in a high wind.

For your postwar peace of mind, you should know that there are a number of

(*Turn to page 252*)


ROSTER OF HELICOPTER PILOTS & STUDENTS
PILOTS
STUDENTS OF C. L. MORRIS
DOUGLAS M. KILPATRICK COL. A.A.F. JUNE 4, 1942
M.V. LEE COL. A.A.F. JULY 23, 1942
P.F. CABEL COL. A.A.F. SEPT 2, 1942
DECEASED PRIOR TO COMPILATION OF THIS ROSTER.

Original of this autographed roster of helicopter pilots and students is prized by author.

THE ECONOMIC FUTURE OF AVIATION TECHNOLOGY

PART II

By FREDERIC FLADER,
President, Frederic Flader Co., Consulting Aeronautical Engineers

Continuing his succinct examination of air transport capacities and costs, the author details the potentials of three typical planes—airline craft representing present, immediate-postwar, and future designs. Then he carefully analyzes their relative operating expenses in the light of factors of competition.

Frederic Flader has been closely identified with American aviation progress since the end of World War I. Graduated from Carnegie Institute of Technology in 1920, he has been continuously engaged ever since in aeronautical engineering work. During these years he was associated with the development of several types of airline planes and with their licensing.

Until recently, he was connected with the Curtiss-Wright Corp., having acted during the past eight years first as assistant chief engineer, then as chief engineer, of the company's Airplane Division at Buffalo. As chief engineer, he supervised development and production engineering work on such craft as the A-18 twin-engine attack plane, the "Hawk" series of pursuits, and later the C-46 "Commando." He is a lieutenant commander in the U. S. Naval Reserve and a Fellow in the Institute of the Aeronautical Sciences.

Announcement now comes that this broadly experienced engineer has established a firm at Buffalo known as the Frederic Flader Co. Purpose of this organization will be the furnishing of consultation, design, and airline operation engineering services.

WE HAVE NOTED (Part I, page 120, June AVIATION) how airline passenger business enjoyed a steady and very satisfactory increase before the war but that meanwhile the rise in airmail and air express shipments was slow. Our statistical data showed in particular that the 2,700,000 ton-miles of air express in 1940 was an insignificant percentage of the total less-than-carload rail express and rail freight.

Superiority of the airplane in speed over rail and truck will not be the dominating factor in procuring any considerable increase in express business for the airlines. Cost is the most important consideration for the vast majority of all shipments, and for this reason the airplane must compete on a dollar-and-cents basis with rail express. If this is possible, then a very large market will be opened for the airlines.

Purpose of this article is to carefully analyze the expense of operation of three different types of aircraft. This analysis will show a trend towards a very substantial reduction in the ton-mile costs in airline operation. The expenses which will be developed in actual operation will vary with the operator—according to his efficiency, the terrain, weather conditions over his route, airline miles flown per year, load factor, and many other variables.

The figures, however, will not be completely factual, because many economic trends are projected and estimated for the new stabilized peacetime period which is to follow the transition from wartime operation.

Operation expenses which are shown are based primarily on the direct flying costs which may be calculated with reasonable accuracy, varying with the type and efficiency of the airplane. The costs should represent the expenses of the average operator, and the differences between the costs of the several types of aircraft should be accurate. This enables a cost trend to be established which will show, at least in a qualitative sense, the future possibilities of the airplane as an economic factor in the transportation business.

Three types of aircraft have been selected for comparison, being chosen to represent: (a) A type currently used in civil airline operation which will continue to be used for some time after the war, (b) a type which has been developed as a military transport and will be available for civilian use after the war, and (c) a future type of large size designed primarily as a cargo carrier.

This third type has been designed through the basic stages with a mass of supporting data concerning its aerodynamic, performance, weight, and structural characteristics. The design represents a type which is possible of achievement by competent aeronautical engineers, ready for operation in approximately five years after the war.

For comparative purposes the operation expenses are shown for both all-passenger and all-cargo operation, except for the last type, which is believed to be most suitable for a combination service.

The future type is calculated as in the 200,000-lb. class, with a cruising speed of 235 mph., and large enough to carry a substantial load of passengers and a large tonnage of cargo. It is estimated that this type of airplane will be suitable for use for high speed short runs at the beginning and close of the business day to

Table I—Percentage of Pounds of Air Express to Tons of Rail Express Shipments for May 1930

	To	Percentage (in rising order)
From New York City	Philadelphia	.94
	Baltimore	1.1
	Boston	2.5
	Buffalo	2.5
	Pittsburgh	2.5
	Cleveland	5.3
	Washington	5.9
	St. Louis	7.3
	Milwaukee	8.0
	Chicago	12.8
	Detroit	16.8
	San Francisco	22.0
	Los Angeles	31.0

accommodate large numbers of passengers, and for long overnight trips with fewer passengers and relatively heavy express loads. This type of service would fill the needs and convenience of a large number of those travelers who primarily wish to save business hours and/or gain hours which they may spend at home. For more frequent schedules during the day and night hours, smaller airplanes would be used.

An example of one schedule to be offered is an overnight flight leaving the West Coast at 6 p. m. and arriving on the East Coast at 8:30 a. m. next morning, with one stop between (and allowing three hours for the difference in time).

Fig. 2 (Part I) indicated that the greatest volume of cargo shipments by air in comparison with shipments by rail are for the longer distances. The accompanying Table I shows the percentage of pounds of air express per tons of rail express from New York to 13 other large cities.

If more extensive statistical information will substantiate these data, then it will be of advantage to emphasize long-haul air express service and short-haul passenger service. For short trips which will consume up to 1½ hr. flying time it has been assumed that 200 passengers may be carried with a relatively smaller express cargo, and for longer trips 100 passengers may be accommodated with varying cargo loads, according to distance.

A summation of the airline and ground operations expenses is given in Table II and is shown graphically by means of the curves of Figs. 4 and 5.

Direct Flying Expenses have been calculated by the Mentzer-Nourse method based on the airplane performance characteristics of Table III. A 65 percent operating load factor is assumed so that the direct flying costs per revenue ton-mile are increased due to the average flight being made with 35 percent of the payload capacity not in use.

Indirect Flying Expenses include those flight operation expenses which are not directly related to the operation of the airplane. These costs cover the operation and maintenance of ground installations, including hangars and other buildings, communications, meteorological services, and station equipment. Statistical data show that the ratio of indirect to direct expense was about 45 percent for carriers flying 20 million plane miles annually from 1938 through 1941. It is believed reasonable that there will be a 15 percent reduction in this cost for the postwar period. This has been assumed for the purposes of preparing expense figures.

Traffic & Advertising is taken at 2c per ton-mile for both all-passenger and all-cargo services, since it is believed that the amount of promotional expenditure will be about the same. For a combination passenger and cargo operation the promotional expense would be higher. A graduated expense is shown for airplane C to allow for intensive promotion of passenger travel for short hauls and approaching all-passenger or all-cargo operation for the long trips in which the major load is cargo.

Table II—Summation of Flying and Ground Expenses for Three Types of Transport Aircraft in the Postwar Period

	A. 1935–1944 All-Passenger			B. Immediate Postwar All-Passenger				C. Future Combination Passenger & Cargo				
Range In Miles	250	500	750	250	500	750	1,000	250	500	750	1,000	1,250
Direct flying costs per ton-mile	.173	.204	.260	.120	.125	.140	.163	.058	.049	.050	.051	.0535
Direct flying costs per ton-mile, 65% load factor	.266	.314	.400	.185	.192	.215	.251	.089	.075	.077	.078	.082
Indirect flying costs per ton-mile	.083	.083	.083	.083	.083	.083	.083	.060	.045	.046	.046	.047
Total direct & indirect flying costs per ton-mile	.349	.397	.483	.268	.275	.298	.334	.149	.120	.123	.124	.129
Traffic & advertising expense per revenue ton-mile	.020	.020	.020	.020	.020	.020	.020	.053	.035	.036	.037	.037
Total direct, indirect, & traffic & advertising expense per revenue ton-mile	.369	.417	.503	.288	.295	.318	.354	.202	.155	.159	.161	.166
General & administrative expenses, approx. 6% of others	.022	.025	.030	.017	.018	.019	.021	.012	.009	.009	.0095	.010
Total airline operating expense per revenue ton-mile	.391	.442	.533	.305	.313	.337	.375	.214	.164	.168	.1705	.176
Ground handling expense (Railway Express service)	.....	.....	.....	.....	.....	.....	.....	.036	.060	.059	.058	.057
Total operating expense	.....	.....	.....	.....	.....	.....	.....	.250	.224	.227	.2285	.233

	A. 1935–1944 All-Cargo				B. Immediate Postwar All-Cargo			
Payload In Tons	3.1	2.9	2.7	2.5	6.8	6.2	5.6	5.0
Direct flying costs per ton-mile	.1272	.1337	.1425	.1528–	.0837	.0840	.0898	.0991
Direct flying costs per ton-mile, 65% load factor	.1957	.206	.2193	.2353–	.1288	.1292	.1381	.1524
Indirect flying costs per ton-mile	.0326	.0326	.0326	.0326–	.0326	.0326	.0326	.0326
Total direct & indirect flying costs per ton-mile	.2283	.2386	.2519	.2679–	.1614	.1618	.1707	.1850
Traffic & advertising expense per revenue ton-mile	.0200	.0200	.0200	.0200–	.0200	.0200	.0200	.0200
Total direct, indirect, & traffic & advertising expense per revenue ton-mile	.2483	.2586	.2719	.2879–	.1814	.1818	.1907	.2050
General & administrative expenses, approx. 6% of others	.0130	.0130	.0130	.0130–	.0130	.0130	.0130	.0130
Total airline operating expenses per revenue ton-mile	.2613	.2716	.2849	.3009–	.1944	.1948	.2037	.2180
Ground handling expense (Railway Express service)	.0800	.0800	.0800	.0800–	.0800	.0800	.0800	.0800
Total operating expense	.3413	.3516	.3644	.38009	.2744	.2748	.2837	.2980

Table III—Characteristics of the Airplanes

A. 1935–1944 Transport	*All-Passenger*				*All-Cargo*			
Gross weight	25,200				25,200			
Weight Empty	17,060				15,060			
Useful load	8,140				10,140			
Number of passengers	21	19	17	15				
Capacity cargo in tons					3.1	2.9	2.7	2.5
Capacity payload in tons	2.1	1.9	1.7	1.5	3.1	2.9	2.7	2.5
Crew	3				2			
Block speed	166	169	171	172	166	169	171	172
Trip distance	435	545	655	770	435	545	655	770

B. Immediate Postwar Transport	*All-Passenger*				*All-Cargo*			
Gross weight	45,000				45,000			
Weight empty	31,100				27,500			
Useful load	13,900				17,500			
Number of passengers	50	44	38	32				
Capacity, cargo in tons					6.8	6.2	5.6	5.0
Capacity, playload in tons	5.0	4.4	3.8	3.2	6.8	6.2	5.6	5.0
Crew	3				2			
Block speed	172	188	194	197	172	188	194	197
Trip distance	250	500	750	1,000	250	500	750	1,000

C. Future Transport	*Passengers & Cargo*				
Gross weight	200,000				
Weight empty	100,000				
Useful load	100,000				
Number of passengers	200	100	100	100	100
Capacity, cargo in tons	16.67	29.92	38.07	26.24	24.50
Capacity, payload in tons	36.67	39.92	38.07	36.24	34.50
Crew	7	7	7	7	7
Block speed	181	197	203	206	208
Trip distance	250	500	750	1,000	1,250

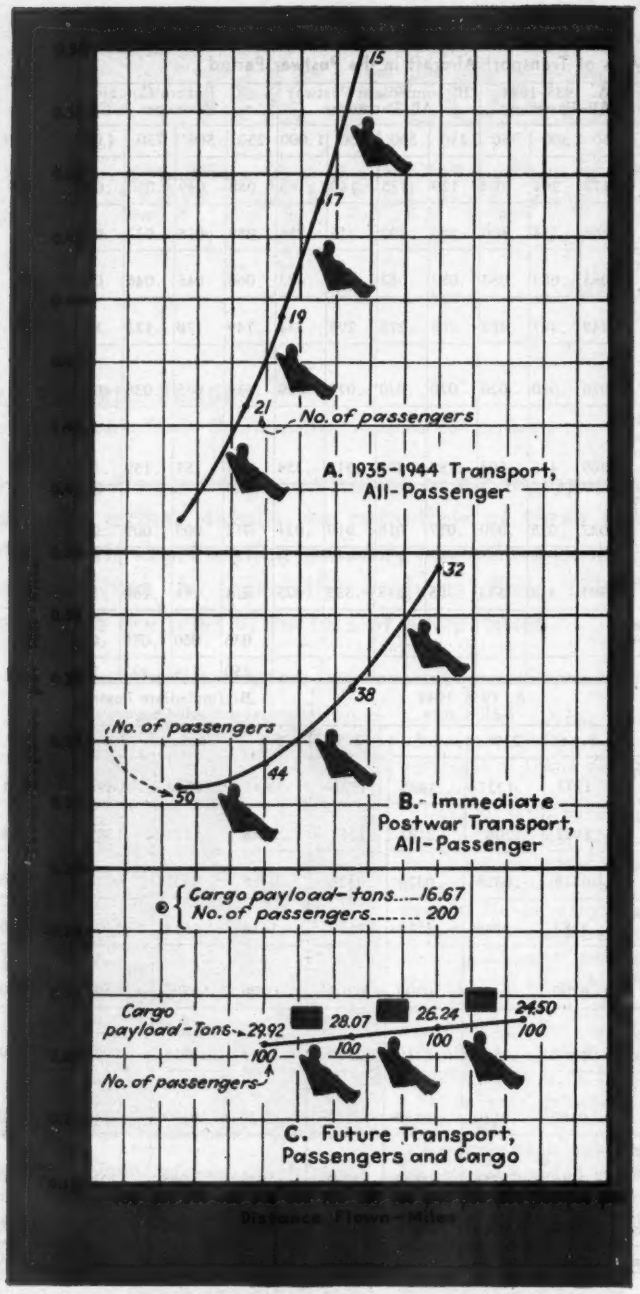


Fig. 4.

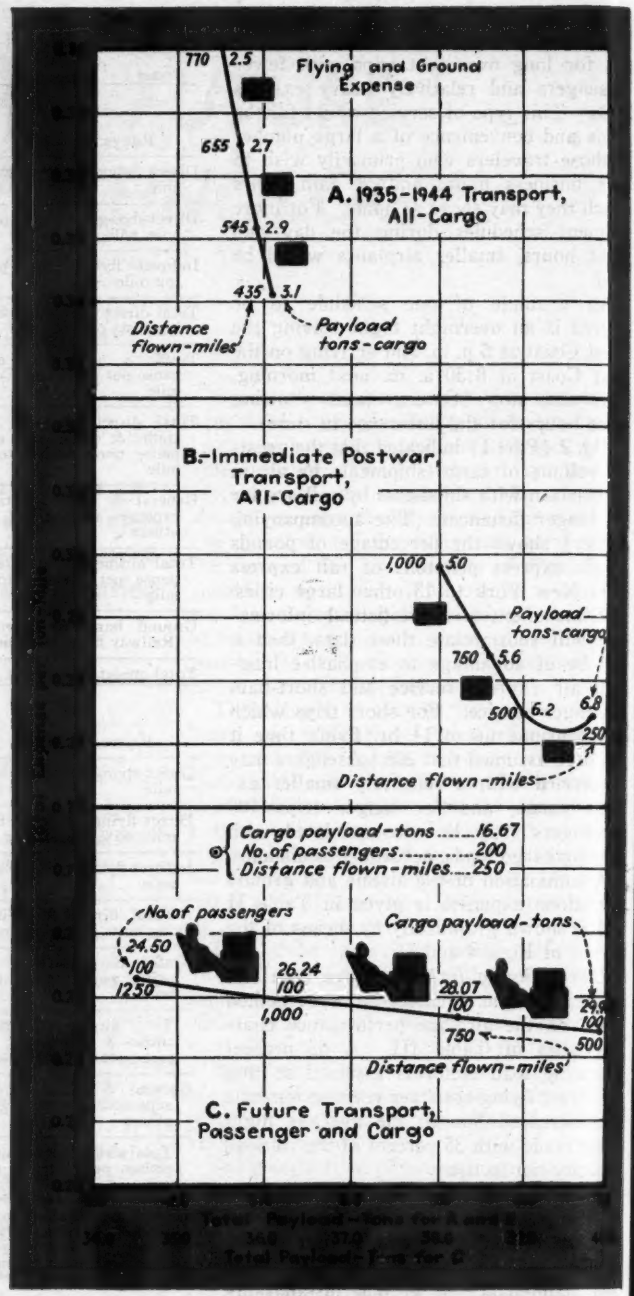


Fig. 5.

General & Administrative Expenses include salaries of officers, clerks, and attendants, legal costs, taxes, and other miscellaneous expenses of a general and administrative character. Experience in airline operations has developed costs of 6.7 percent of all other expenses with an average revenue pay load of 2½ tons and a traffic volume of 100 million ton-miles annually. For the postwar period's larger average revenue loads the figure is conservatively estimated to be 6 percent of all other operating expenses.

Summation of all of these expenses represents the operating expense for all-passenger services. These expense totals include only line haul or airport-to-airport costs. For cargo transportation additional expense must be allowed for pick-up and delivery of shipments by motor truck and for terminal operations, billing, sorting, dispatching, and loading and unloading trucks and aircraft. These costs are called ground-handling expenses.

Ground Handling Expenses at the present time are relatively high[5] but it is reasonable to expect that the economies which can be made in the services offered for long hauls will substantially reduce these costs. Elimination of unscheduled pick-up and delivery, and the establishment of overnight service with scheduled pick-up near the close of business hours and delivery at the beginning of the next business day is likely to offer acceptable service at reduced cost.

From an examination of the various elements involved it has been estimated that ground handling expenses will average 8c per ton-mile for cargo transportation in the postwar period.[5] In the case of the combined passenger and cargo service the estimated costs have been based on this 8c figure, but the amounts shown have been reduced to allow for the fact that a part of the loads carried are passengers.

It will be noted that Table II and the curves of Figs. 4 and 5 show the total operating expenses for all-passenger, all-cargo, and the combination services.

Taking a 750-mi. flight distance as a basis, this analysis shows that the probable reduction in all costs of operation for cargo between the presently used 1935-1944 type and the future transport is approximately 14c. per ton-mile, or about 38 percent. This indicates the possibility of a similar reduction applying to the 58c. per ton-mile charged for air express in 1940. This should establish a new rate of about 35c. per ton-mile. On this basis the airlines in postwar operation, with the degree of improvement in airplanes indicated, should afford capacity for at least 145,000,000 ton-miles. This would represent about

(*Turn to page* 250)

Where Are Those Marketing Plans?

By **JOHN H. FREDERICK,** *Professor of Transportation & Industry, School of Business Administration, University of Texas*

Recounting the disconcerting experience of a potential distributor, this terse case history throws down a pointed challenge to those manufacturers who will enter the post-victory light plane field.

THERE ARE literally thousands of men who want to get into the private or light plane market as dealers or distributors, as soon after the war as possible. Some are just thinking about it; others are taking steps to find out what the possibilities are. Naturally, they turn to the present light plane manufacturers for information. But most of them will be doomed to disappointment if their experiences are anything like those of a friend of mine in the oil business.

This man, with adequate capital available, is sincerely anxious to establish a light or private plane dealership in the Southwest. He came to me recently to see if I could help him gather data on manufacturers' plans for postwar distribution and thus trace out a representative picture to aid him in formulating his own plans.

As the first step, the following questions were put (via my friends business letterhead) to 25 personal plane manufacturers:

1. What minimum capital outlay will you deem necessary for a sales and service organization serving the various-sized territories which you contemplate setting up?

2. Do you propose to grant exclusive agencies? If so under what conditions?

3. How many different models of private aircraft do you propose to place on the market during the immediate postwar years? What is the proposed price of each model?

4. What commission will be offered dealers?

5. What are your plans for sales help and promotion to aid dealers?

Surprising revelation of this survey is the apparent lack of postwar planning on the part of these manufacturers. Only 18 of 25 even deigned to reply and of these, only 5 attempted to answer the questions with any degree of completeness. Several respondents who did not answer the queries pointed to their complete absorption in the production of military equipment as the principal reason for being without postwar plans. Others either professed to be in the process of making their plans or merely stated that they had no definite postwar plans as yet. One company sent only a calendar with no letter at all.

From the replies of those who are approaching completion of their postwar plans, it is obvious that they plan to continue their prewar methods of distribution. They will market their planes through distributor and/or dealer arrangements, the agencies being granted exclusive operating rights in their specific territories. Other manufacturers may or may not follow this exact procedure, but the evidence indicates that the majority will.

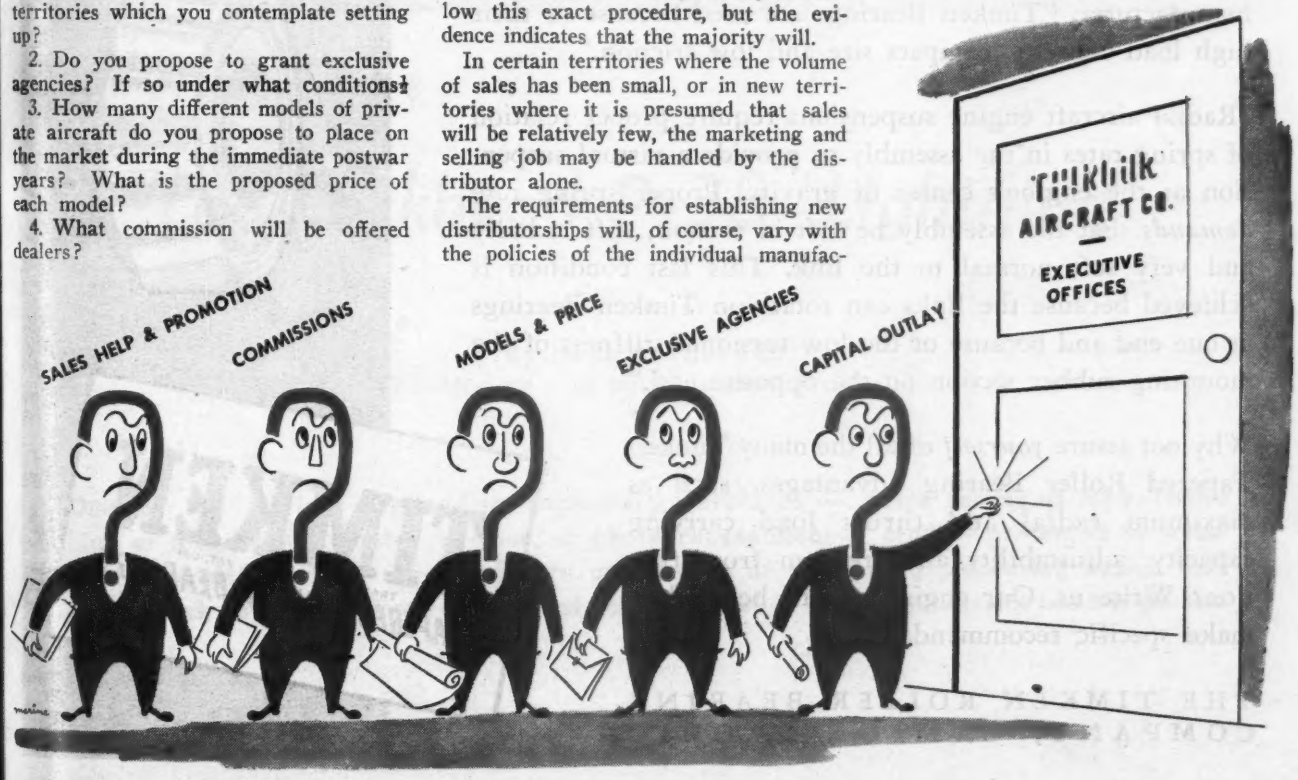
In certain territories where the volume of sales has been small, or in new territories where it is presumed that sales will be relatively few, the marketing and selling job may be handled by the distributor alone.

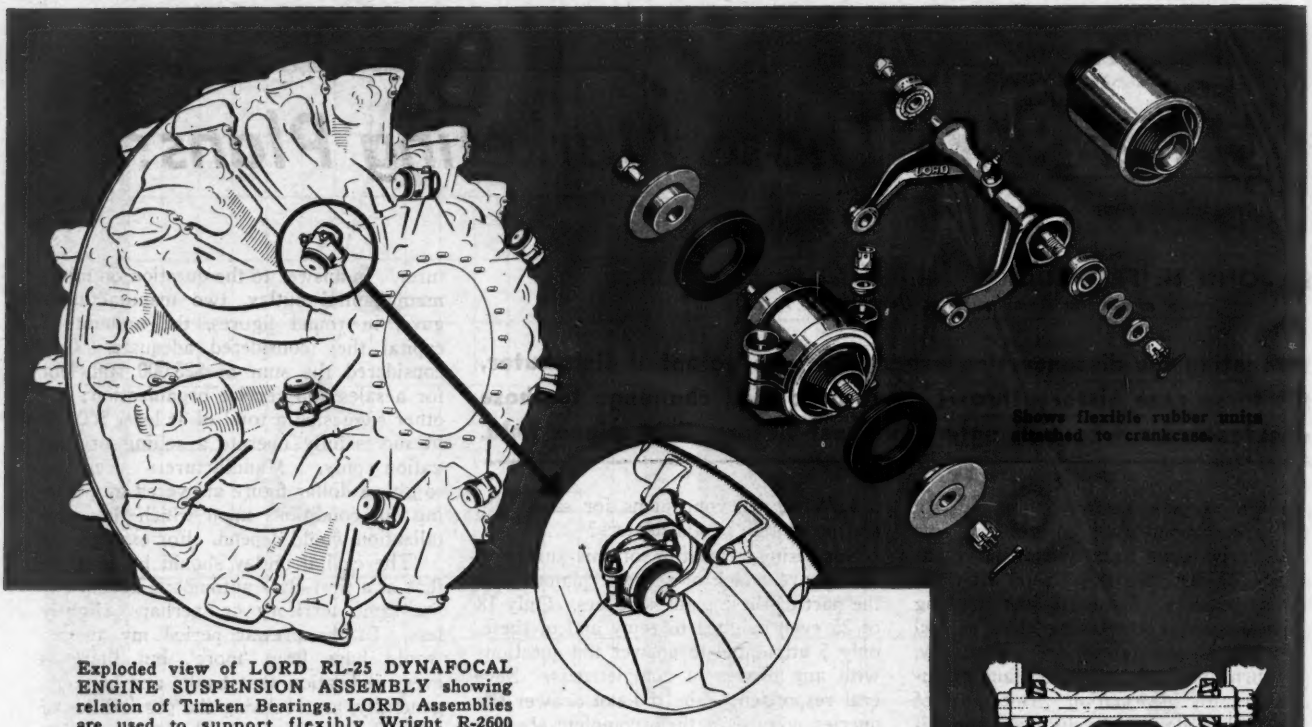
The requirements for establishing new distributorships will, of course, vary with the policies of the individual manufacturer. In answer to the question on minimum capital outlay, two manufacturers gave, in round figures, the amount of capital they considered adequate. One considered the sum of $25,000 sufficient for a sales and service organization; the other suggested a total of at least $60,000 to successfully operate a selling orginazation only. Manufacturers declining to give a dollar figure answered by pointing out conditions upon which the capitalization would depend. For example:

"The capital outlay should be equal to that of a first-class automobile agency for the same territory or, perhaps, slightly less. In the prewar period my answer would have been 'more', but there is every indication that banks and bankers, generally, are realizing the possibilities of aircraft financing after the war and that aircraft dealers will be able to handle their paper at reasonable rates through their local banks, finance their stocks and probably use their used airplanes as loan collateral."

Other factors mentioned that might determine capital outlay were: (1) Whether or not private airports and buildings would be constructed by the prospective distributor; (2) the size of the territory to be served and the sales estimate for that territory; (3) the completeness with which the territory will be served; and (4) whether or not service facilities

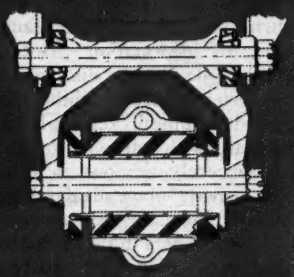
(*Turn to page 267*)



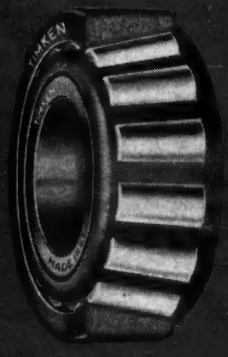


Exploded view of LORD RL-25 DYNAFOCAL ENGINE SUSPENSION ASSEMBLY showing relation of Timken Bearings. LORD Assemblies are used to support flexibly Wright R-2600 radial aircraft engines.

Shows flexible rubber units attached to crankcase.



Completed assembly after engine is hooked to mounting ring. Due to angularity of links, virtual center of gravity support is achieved, and flexibility of mounting assembly allows free movement in all directions about engine C. G.



Timken Bearings

HELP LORD DYNAFOCAL ASSEMBLIES ISOLATE ENGINE VIBRATION . . .

"In the Lord link-type Dynafocal suspensions," writes the manufacturer, "Timken Bearings are used because of their high load capacity, compact size and low friction."

"Radial aircraft engine suspensions require proper relation of spring rates in the assembly to provide a virtual suspension at the engine's center of gravity. Proper spring rate *demands* that the assembly be soft in torsion, stiff radially and very soft normal to the link. This last condition is achieved because the links can rotate on Timken Bearings at one end and because of the low torsional stiffness of the mounting rubber section on the opposite end."

Why not assure *yourself* of all the many Timken Tapered Roller Bearing advantages, such as maximum radial and thrust load carrying capacity, adjustability and freedom from friction? Write us. Our engineers will be glad to make specific recommendations.

THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO

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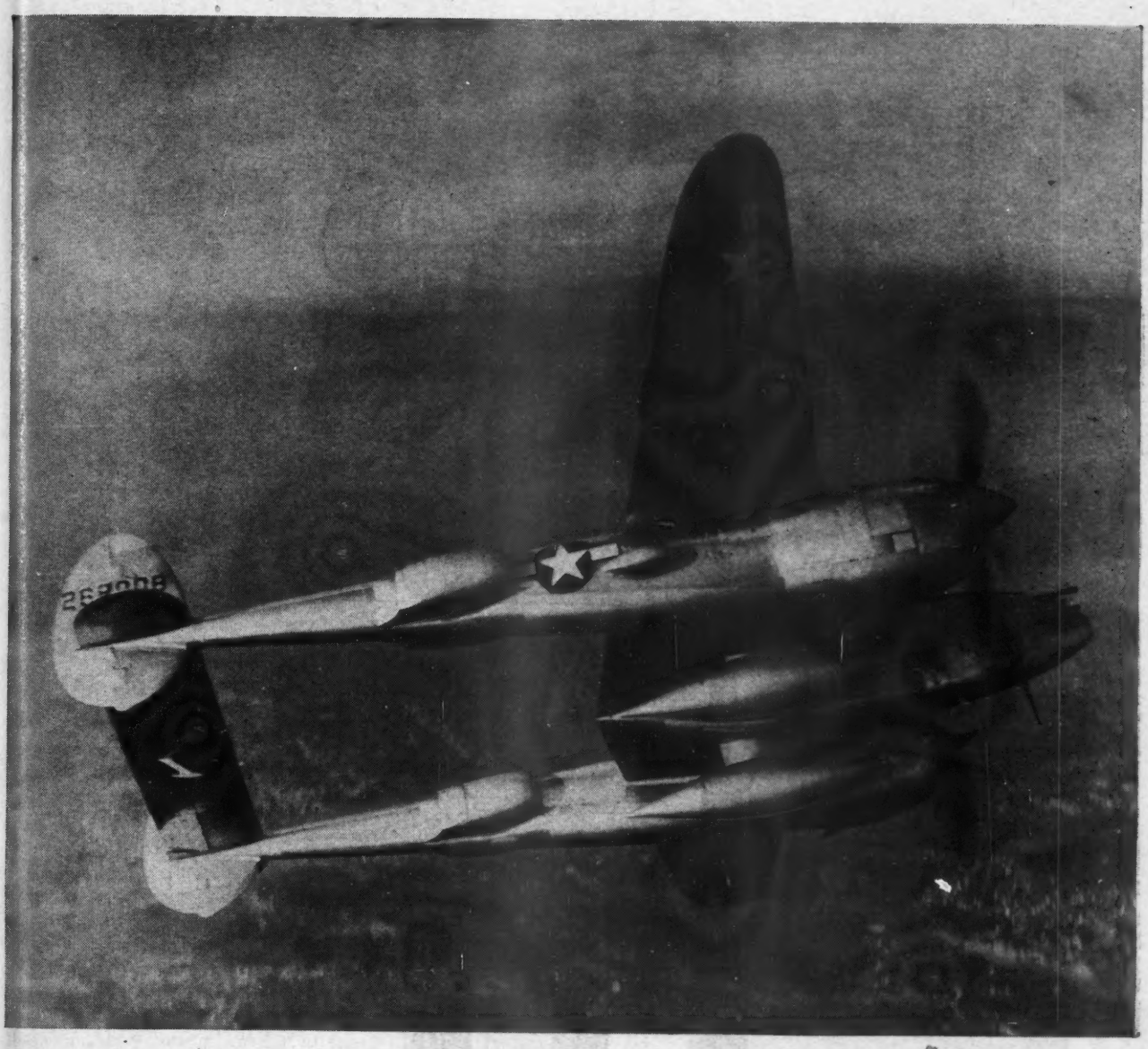
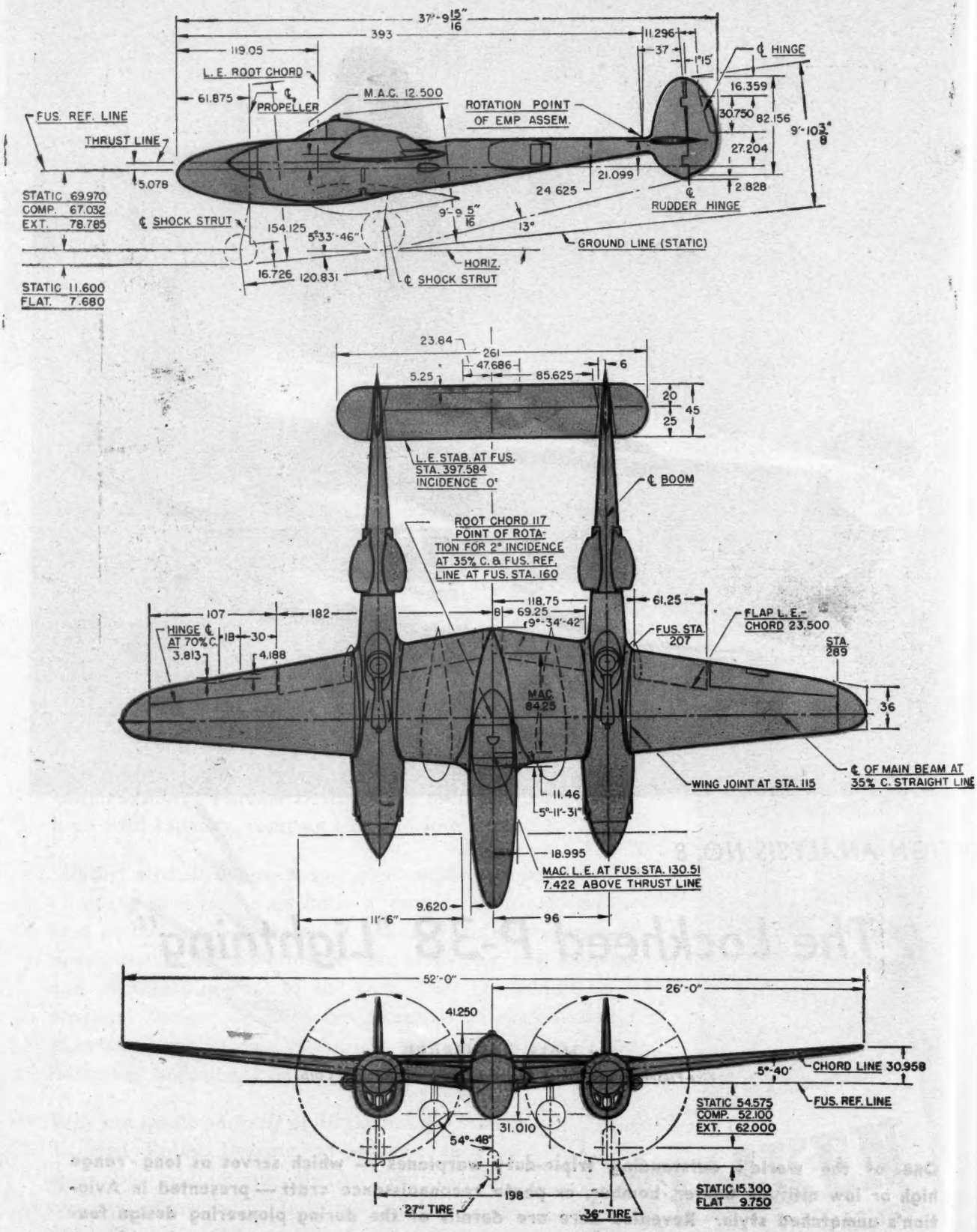


DESIGN ANALYSIS NO. 8

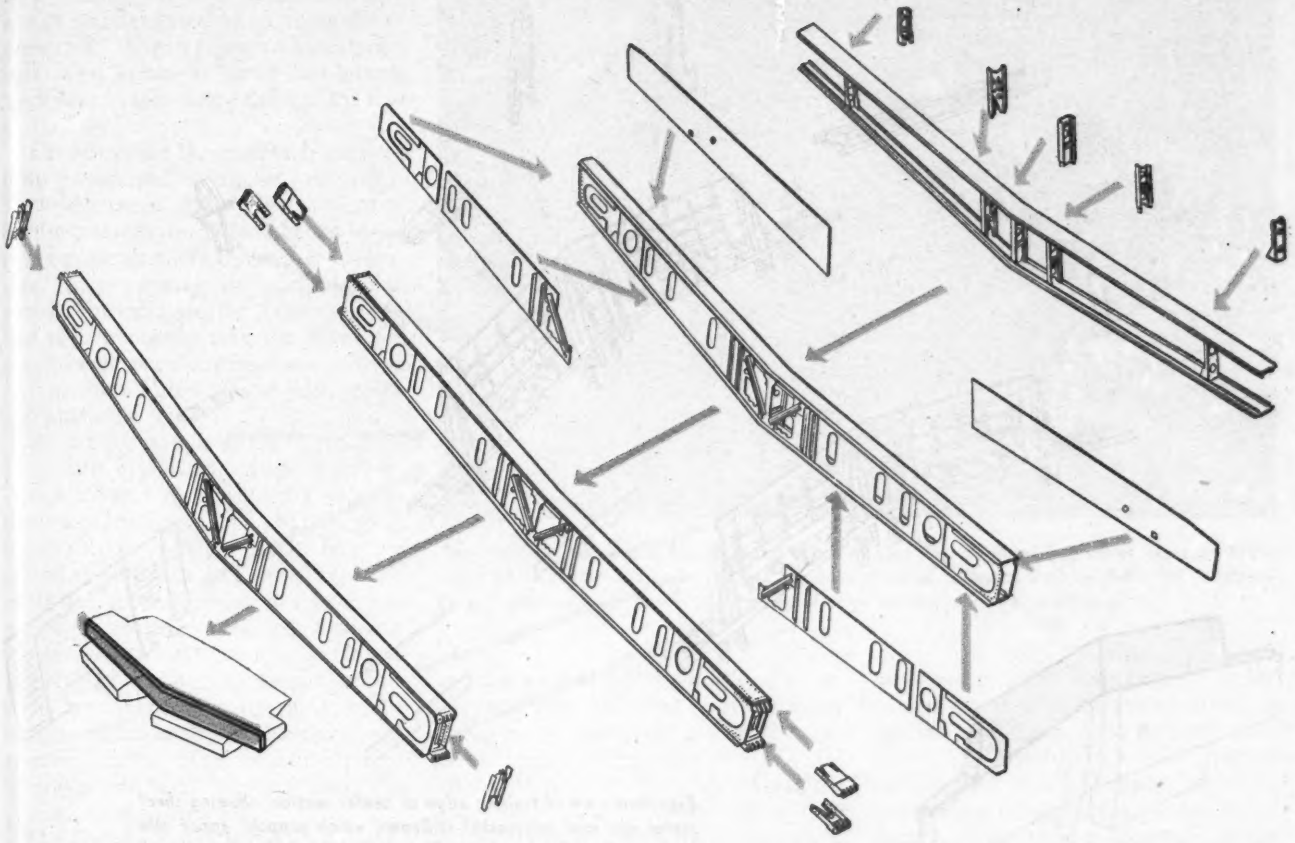
The Lockheed P-38 "Lightning"

By **HALL L. HIBBARD**
Vice-President and Chief Engineer, Lockheed Aircraft Corp.

One of the world's outstanding triple-duty warplanes — which serves as long-range high or low altitude fighter, bomber, or photo reconnaissance craft — presented in Aviation's unmatched style. Revealed here are details of the daring pioneering design features which have made it one of the most controversial as well as successful combat planes.



Three view silhouette of Lockheed P-38 "Lightning" fighter. All dimensions on wing surface are given neglecting incidence and are measured horizontally. Dihedral angle is measured at basic chord plane and does not include incidence. Wing is built with 5 deg. 40 min. dihedral and then rotated about intersection point of main beam centerline and wing chord line at centerline of ship until 2 deg. incidence is obtained. All dimensions referring to empennage vertical surfaces only are rotated 1 deg. 15 min. counterclockwise of vertical and horizontal, respectively.

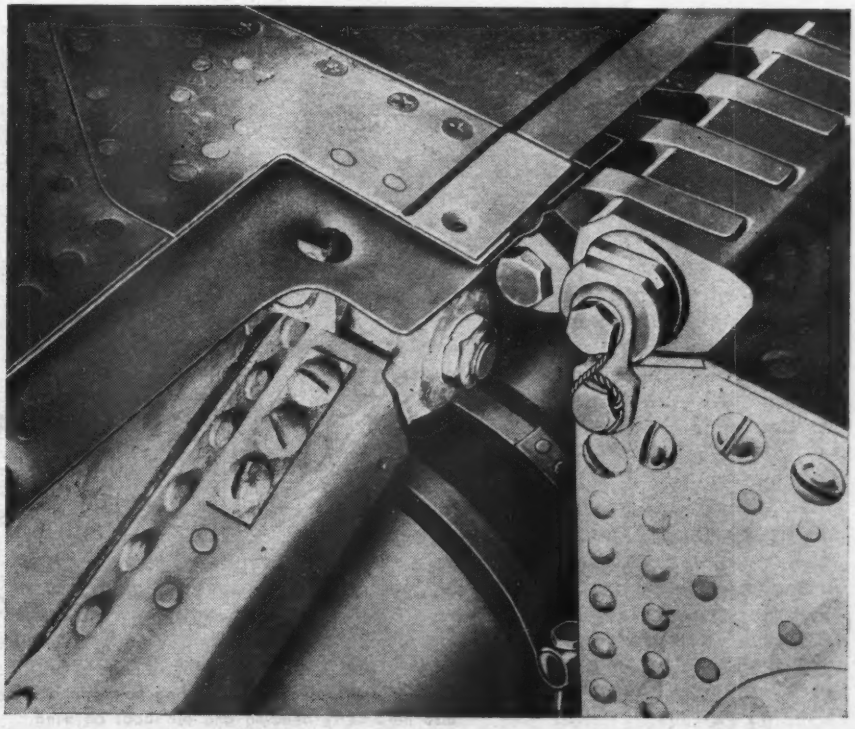


Exploded view of main beam in center section, showing double web, box type construction. Note variety of bulkheads, and upper and lower channels (right), aft, front inboard, and front outboard web assemblies (center right), upper and lower wing fittings (center left), and completed center section beam with end bulkheads (left). Position of main beam in center section is shown at extreme left.

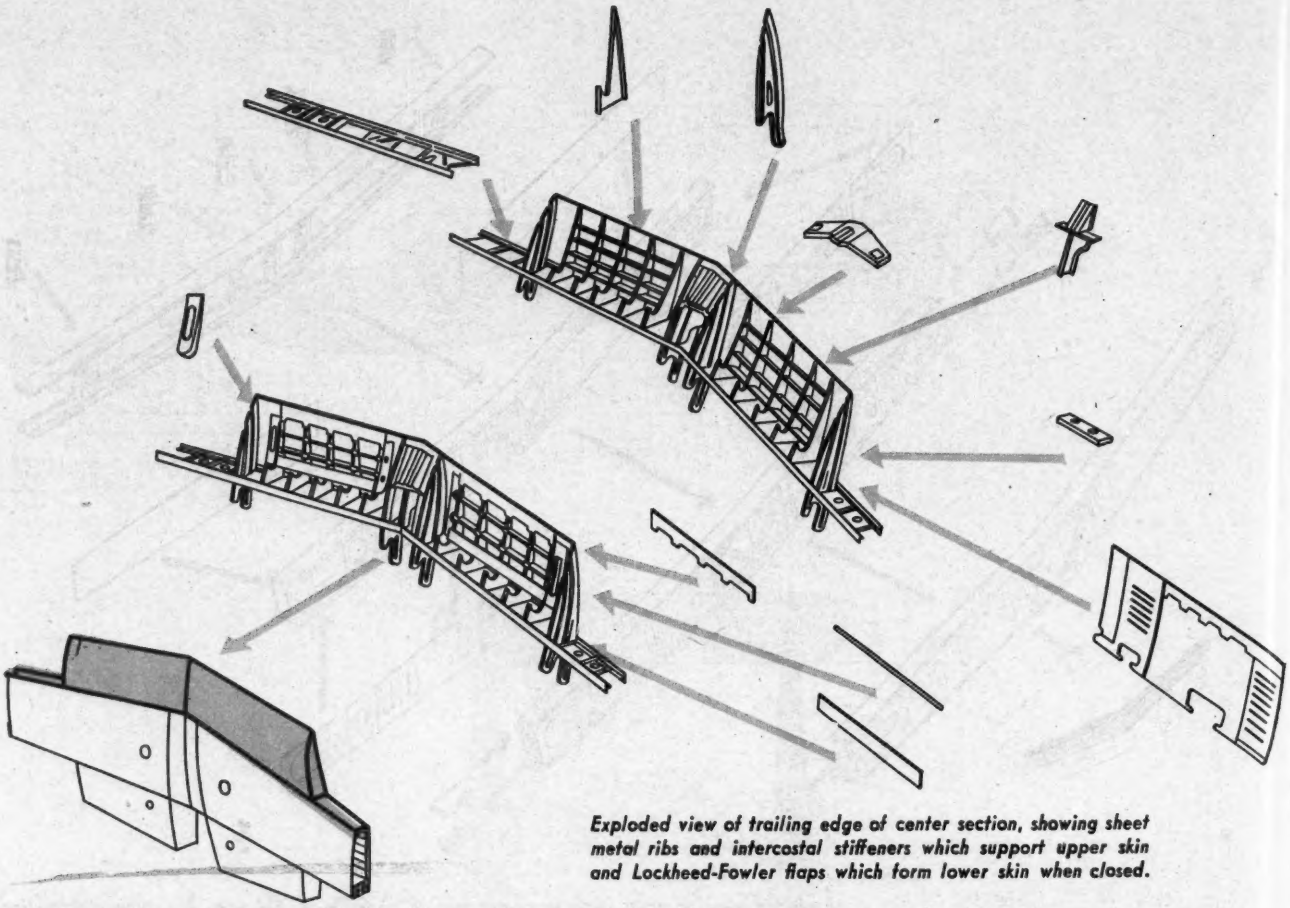
THE Lockheed P-38 *Lightning* fighter has been quite appropriately called the most controversial airplane ever adopted by the U.S. armed services. In thousands of sorties and hundreds of combat victories many of the points of controversy have been resolved, but there still persists much that is either erroneous or due to misunderstanding.

Perhaps some of the derogatory items in the P-38 legends are traceable to the superlative requirements contained in the Army's specifications. To meet or surpass those requirements, and more recently to modify the P-38 as war experience and developments required, it has been necessary to do considerable pioneering. Particularly is that true in the higher speed ranges. And for such pioneering, the *Lightning* has had to accept the penalties of popular misunderstanding and the criticisms most pioneers undergo.

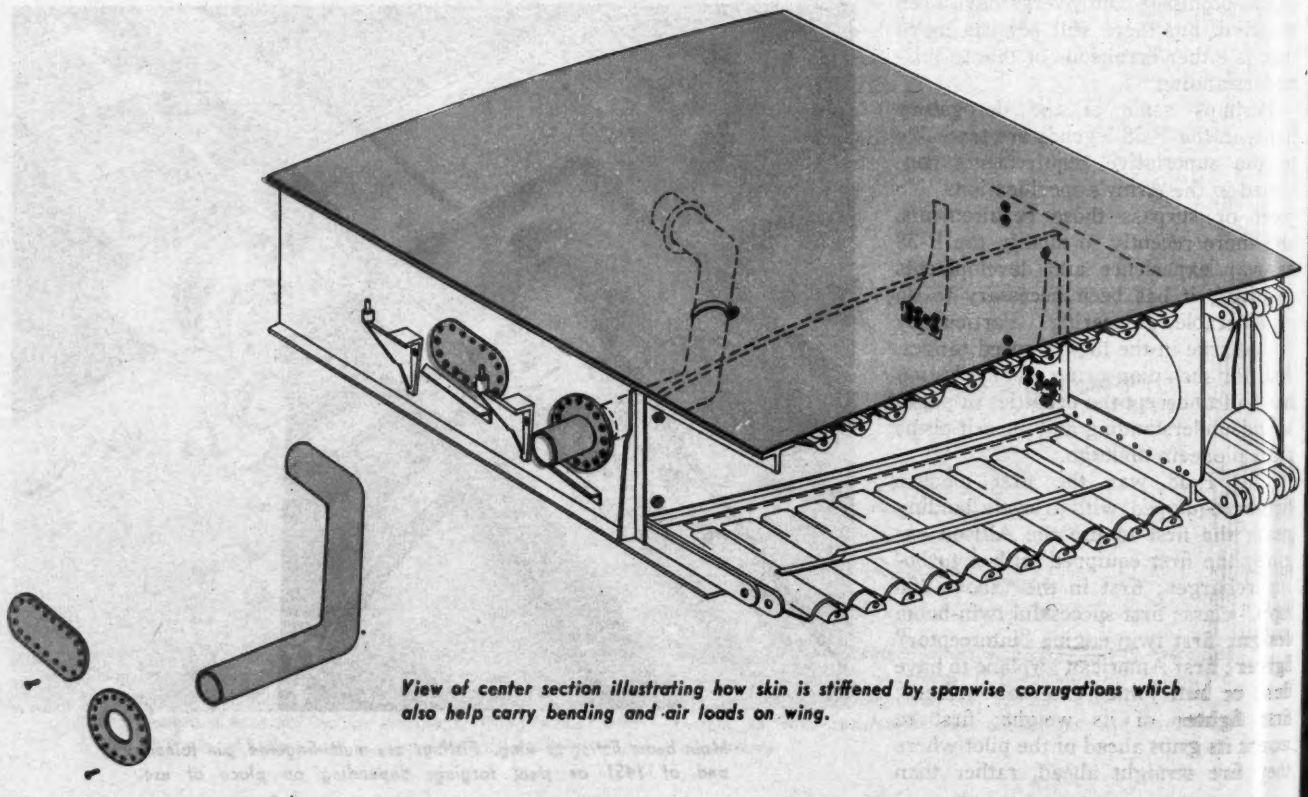
The P-38 was the first modern fighter equipped with tricycle landing gear; the first to use the Allison engine; the first equipped with a turbosupercharger; first in the "above 400 mph." class; first successful twin-boom design; first twin-engine "interceptor" fighter; first American airplane to have flush or butt joined external surfaces; first fighter of its weight; first to mount its guns ahead of the pilot where they fire straight ahead, rather than



Main beam fitting at wing. Fittings are multi-fingered, pin joined, and of 14ST or steel forgings depending on place of use.



Exploded view of trailing edge of center section, showing sheet metal ribs and intercostal stiffeners which support upper skin and Lockheed-Fowler flaps which form lower skin when closed.



View of center section illustrating how skin is stiffened by spanwise corrugations which also help carry bending and air loads on wing.

in a "cone"; first to make extensive use of stainless steel; first to be delivered under its own power to bases overseas; first fighter to carry and launch torpedoes; and first fighter to tow gliders.

The list could be continued, particularly in the field of combat versatility. However, these "firsts" illustrate many of the sources of P-38 legends especially those partially or entirely inaccurate. In pioneering high altitudes and speeds, for example, the *Lightning* has had to temporarily take the blame for operational peculiarities later proven common to all airplanes at such speeds and altitudes.

Versatility now credited to the P-38 is a pure byproduct, rather than designed intent. We designed a superlatively fast, rapid climbing, hard hitting, high altitude fighter. That fact required the ultimate in clean design and great horsepower, which in turn established the plane's other specifications. These in turn have made possible the carrying of bombs and droppable fuel tanks for long range operation. The high speed has made possible the photographic version. And the concentrated firepower has been found excellent for ground strafing missions.

The current P-38J is the 36th development, including several designs which were never built, of the original Lockheed Model 22, and represents seven basic model variations. This evolution has resulted in the airplane now credited with being the fastest, most maneuverable, hardest hitting fighter, with the greatest ceiling, longest range and fastest sustained climb of any now in combat operation.

Dimensionally the *Lightning* is big for a fighter, having a wing span of 52 ft., an over-all length of 37 ft. 10 in., and a maximum height from the static ground line to upper tip of the empennage of 9 ft. 9$\frac{1}{8}$ in. Its weight empty is 12,700 lb. and its normal useful load is 2,000 lb. However, one specification alternate provides for a gross weight of approximately 18,000 lb.

Every design feature of the P-38, as in most successful airplanes, was originated by necessity. The distinguishing twin-booms, for example, were not selected because they would be different. Neither was the twin-boom design originated by Lockheed. Some previous planes of this design, it is true, had not been too successful but for reasons other than the booms. In the *Lightning* they evolved as a logical development of engine nacelles made long to house the engine oil cooler, turbosupercharger, Prestone radiators, and landing gear. Because of the greater nacelle length it was logical to extend them into booms to carry the empennage. Engineering-wise they add nothing or subtract nothing that could not have been achieved in other ways.

Another P-38 design innovation, recently added dive flap developed to offset compressibility effect which shifted lift center. Flaps are built of three layers of flush-riveted sheet, attached by piano-type hinge. Electrically operated, flaps extend to angle of 40 deg.

Necessity was truly the mother of invention in the evolution of the *Lightning* design. The Army specifications, laid down in 1937, were such that power requirements were greater than could be obtained from any single engine then available. Superior speed, rapid climb, high ceiling, and great firepower were the principal objectives demanded by the Army. To them we added placement of firepower where it would be most effective—ahead of the pilot and below his line of vision to provide unexcelled visibility and a distinct advantage in shooting. The pilot can pick up his target quicker and need not get it at the precise apex of a cone of fire such as is necessary when the guns are mounted in the wings.

The P-38 is now credited with speeds above 425 mph. This high speed, plus great maneuverability due to new booster-type aileron control, plus added dive control obtained by specially designed wing flaps, result in a tremendous combat advantage now being demonstrated daily all over the world.

An all-metal, mid-wing, single seater fighter, the P-38's wing is of full cantilever design, constructed in five components: center section, outer panels and tips. The center section, forward booms, and gondola-type fuselage are jig mated and bolted together. Main structural members of the center section are a main beam, located at 35 percent chord, front and rear shear beams, tied together with corrugated and flat 24ST to form a box section in which space is provided for fuel cells.

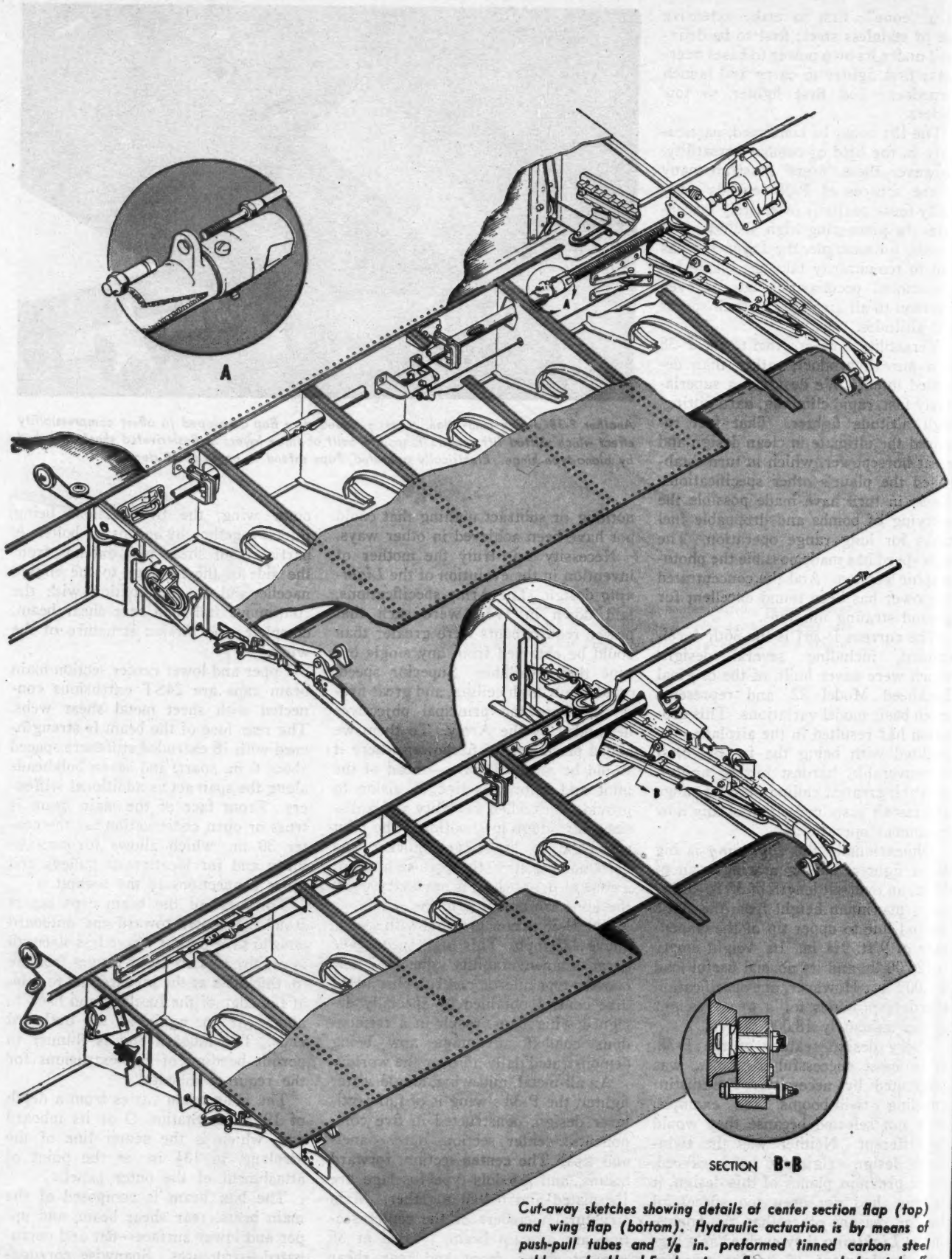
The main beam is double web, box type in the center section, and a single web, modified Wagner type in the outer wing, the two sections being joined together by means of bolts. A partial front shear web extends from the side of the fuselage to the engine nacelle and in combination with the continuous full-span rear shear beam, completes the torsion structure of the wing.

Upper and lower center section main beam caps are 24ST extrusions connected with sheet metal shear webs. The rear face of the beam is strengthened with 18 extruded stiffeners spaced about 6 in. apart, and seven bulkheads along the span act as additional stiffeners. Front face of the main beam is truss or open construction for the center 30 in., which allows for accessibility and for location of pulleys and other connections to the cockpit.

Thickness of the beam caps tapers from the center toward the outboard ends to save weight where less strength is required. This taper ranges from $\frac{7}{16}$ in. thickness at the inboard end to $\frac{7}{8}$ in. at the edge of the fuselage and back to almost $\frac{7}{16}$ in. again at the outboard ends. The inboard end is thinner to permit bending of cap extrusions for the required dihedral.

The main beam varies from a depth of 19 in. at Station O at its inboard end, which is the center line of the airplane, to 13$\frac{1}{2}$ in. at the point of attachment of the outer panel.

The box beam is composed of the main beam, rear shear beam, and upper and lower surface—flat and corrugated—structures. Spanwise corrugations stiffen the skin and help carry bending and air loads on the wing. Webs of the main beam are 5$\frac{1}{4}$ in. apart and .040 ST Alclad aluminum. Corrugations in the center wing section are .064 SRT and .032 SRT



Cut-away sketches showing details of center section flap (top) and wing flap (bottom). Hydraulic actuation is by means of push-pull tubes and 1/8 in. preformed tinned carbon steel cables. Lockheed-Fowler type flaps are used for takeoff, maneuvering, approach, and landing.

Alclad. The upper and lower skin is .040 ST aluminum with lower skin strengthened with an .040 doubler extending inboard from the outboard end to a diagonal line approximately half way to the center line.

The rear shear beam is a single-web, modified Wagner type, constructed of extruded T's and sheet stock.

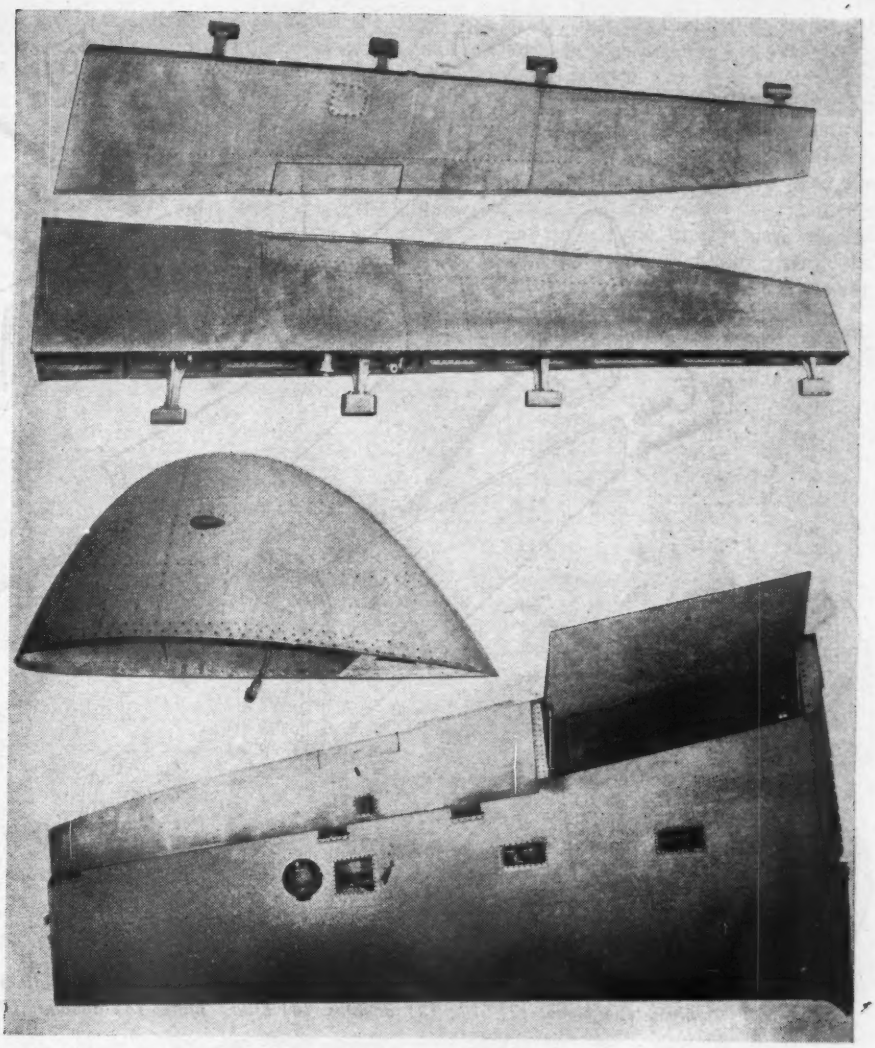
Wing fittings which attach to the upper and lower caps of the main beam are of 14ST forgings and are formed multi-fingered, pin joined. For connection of the outer wing main beam the fittings on the outer wing are multi-fingered steel forgings, to reduce their size and increase the faces carrying shear loads.

Rear shear beam of the outer wing joint is a simple shear fitting, steel pin connection at the upper and lower caps. Corrugations of the surface structure are spliced at the outer wing joint by means of aluminum alloy forgings and tension bolts.

The box structure and leading edge section forward of the main beam extend from the fuselage to the engine nacelles and form a two-cell torsion box which carries torsional loads to the fuselage. The surface structure through the center section is stabilized for a portion of its length from the center line outboard to the edge of the fuselage with ribs built up with sheet metal stampings. The surface structure is unsupported from that line to approximately where the booms attach to provide room for fuel tanks in the box beams and leading edge sections. The leading edge sections have chordwise formers in both upper and lower surfaces instead of ribs extending from the main beam to the front shear beam. The front beam is interrupted at the fuselage and nacelles and the loads are taken across by the box beam between the main and rear spars.

In the gas tank area .025 ST inner skin is riveted to the corrugated stiffener by means of flush rivets. Due to the inaccessibility it was necessary for Lockheed tooling engineers to develop a magnetic bucking bar for this operation, which was typical of the many manufacturing problems posed by the pioneering done in the P-38.

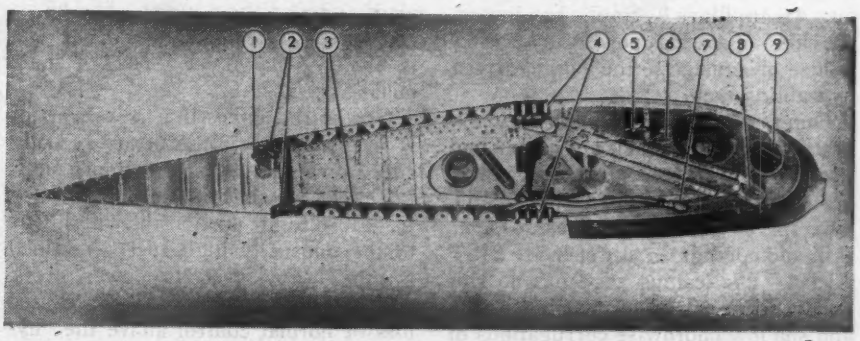
Trailing edge of the center section consists of sheet metal ribs and intercostal stiffeners which support the upper skin, and Lockheed's design of Fowler flaps. Flaps consist of a main spar formed with a sheet metal web and formed sheet metal caps, sheet metal ribs and stringers. They are carried on forged 14ST arms guided on tracks machined from 14ST forgings. They extend from either side of the fuselage outboard to the inner end of the aileron, a distance of approximately



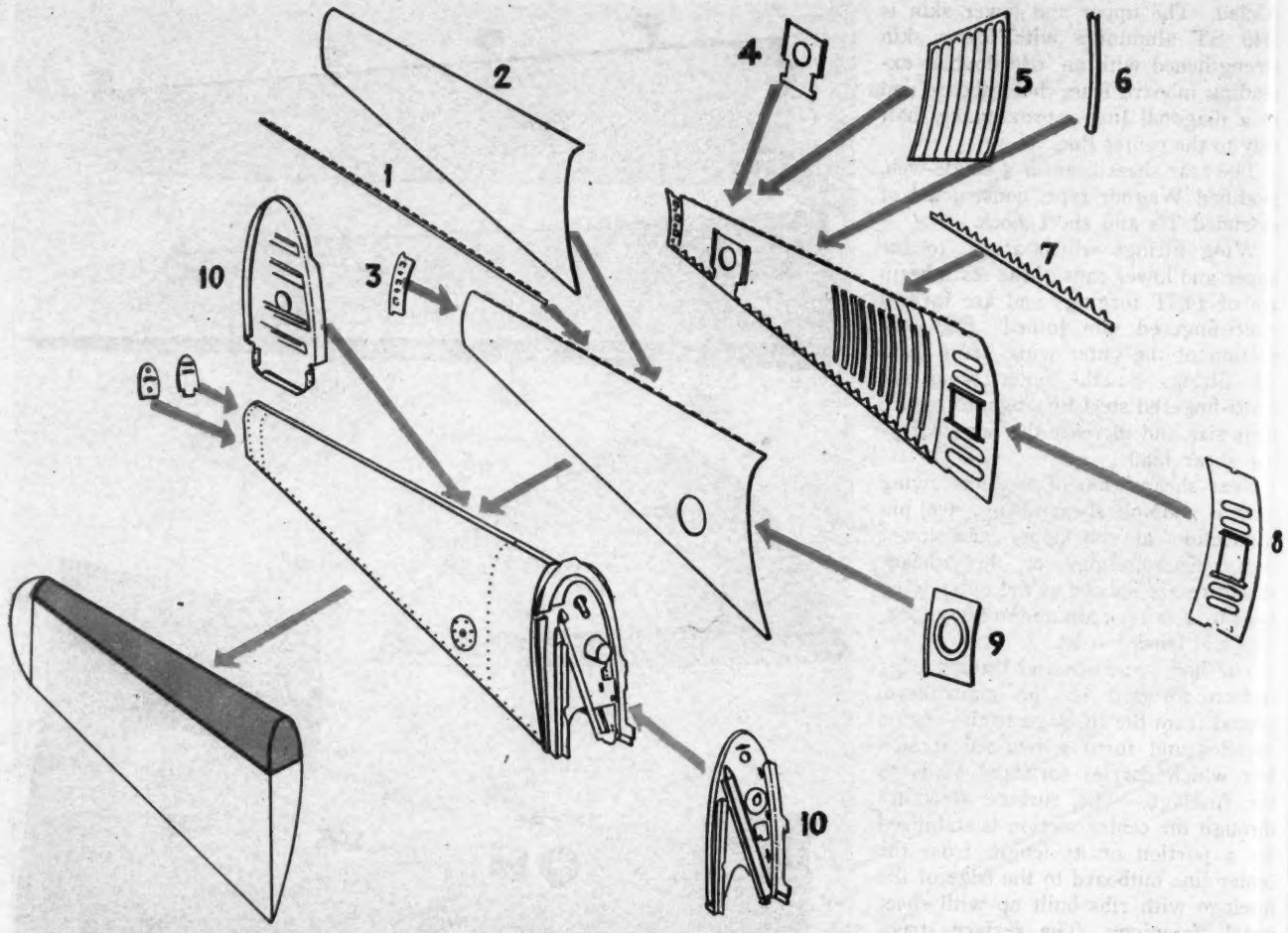
This photo group shows (top to bottom) upper and lower aileron surfaces; wing tip assembly; and lower surface of outer wing panel with flap extended. Wingtip outer skins are spot welded to beaded inner skins, reinforced by two beams. Tips attach to outer panel by flush screws.

180 in., with the exception of a section approximately 43 in. wide, omitted at each boom.

Having a total area of approximately 40 sq. ft., the flaps are secured to the wing by means of eight carriages supported in tracks attached to the flap supporting ribs and providing for extension aft in line with the flight path so that, in extended position, the flap leading edge corresponds approximately to the trailing edge of the wing. The flap is actuated by an irreversible screw driving a guided push-pull tube, which runs outboard from the fuselage through each wing, and to which the



Profile of outer wing panel, showing: (1) flap drive tube; (2) shear beam attaching arms; (3) bathtub fittings; (4) main beam fittings; (5) pitot line connections; (6) fish wires tied to outer panel aileron and aileron tab cables; (7) electrical conduit; (8) wing engine mount lug, and (9) generator blast tube.



Leading edge assembly, outer wing, showing: (1) piano-type hinge; (2) skin; (3) doubler; (4) filler well; (5) corrugations; (6) cap strip; (7) finger plate; (8) doubler; (9) sump well, and (10) ribs.

flap carriages are connected by means of a system of $\frac{1}{8}$-in. extra flexible, preformed tinned carbon steel cables.

All pulleys and other rotating parts of the flap actuating system are mounted on anti-friction type bearings. This mechanism permits the flap to be extended to its optimum setting or held in any intermediate position desired without loading the driving mechanism. The irreversible screw is hydraulically operated, with activation by means of controls in the pilot's cockpit. An auxiliary hydraulic hand pump provides operating power in case of failure or damage to the engine-driven hydraulic pump.

Outer wing panels consist of main beam, rear shear beam, and upper and lower stressed skin, forming a box beam, and hydro-pressed sheet 24ST ribs spaced at 12-in. centers. Outer skin and corrugated stiffener are 24ST Alclad. The leading edge has no ribs and is made up of formed inner skin and shallow chordwise corrugations of 24ST. These are built up of upper and lower halves, joined at the leading edge with piano hinge fittings, and are removable. In earlier models the intercoolers were housed in the leading edge of the wing, which now carries fuel cells.

A flush type leading edge light is incorporated in the left side. The skin, of .040 gage, 24ST Alclad, is flush riveted and butt jointed.

Main beam of the outer wing panel consists of upper and lower beam caps which are 24ST aluminum alloy extrusions, tapering out from the center until a heavier, reinforcing section disappears and the extrusion becomes a plain angle of sheet metal. The lower cap tapers faster than the upper and is finally replaced by a pair of sheet metal angles.

One of the interesting new cases of P-38 pioneering is the use of recently added dive flaps to offset compressibility effect which shifted center of lift from fore to aft portions of wing. Due to the unusually high speeds attained by the heavy P-38 in power dives, shifting of the center of lift caused loss of normal control above the "hydrodynamic" speeds—where air reacts much like water—with a resulting tendency of the plane to go into an outside loop. Since installation of the flaps this characteristic has been overcome.

The flaps are fabricated of three layers of aluminum alloy sheet, flush riveted. They attach, by means of a piano-type hinge, along the same line at which the leading edge of the wing is joined to the outer panel. Actuation is electrical, with a high speed electric motor driving actuating screw mechanisms connected to a curved arm hinged to a fitting on the brace or rearmost of the two panels of the flap assembly. When lowered, the flap stands at an angle of 40 deg. from the lower skin surface line, and at its farthest point is $5\frac{1}{2}$ in. from the wing to the piano hinge by which it is attached to the brace panel. Two actuating mechanisms, side by side at the center, operate each flap, the actuating arms swinging downward through an opening in the wing skin. The flap and brace panels have a combined chord of $15\frac{1}{2}$ in., divided $8\frac{1}{2}$ in. to the flap itself and 7 in. to the brace. Length is 58 in. The mechanism is bolted to a heavy casting anchored to the lower skin structure and two wing ribs between which it is located.

The wing tips are made up of smooth

outer skins spotwelded to beaded inner skins and reinforced with two small spanwise beams each. Attachment is made to the wing by screws. A streamlined formation light is contained in both upper and lower surfaces of these structures.

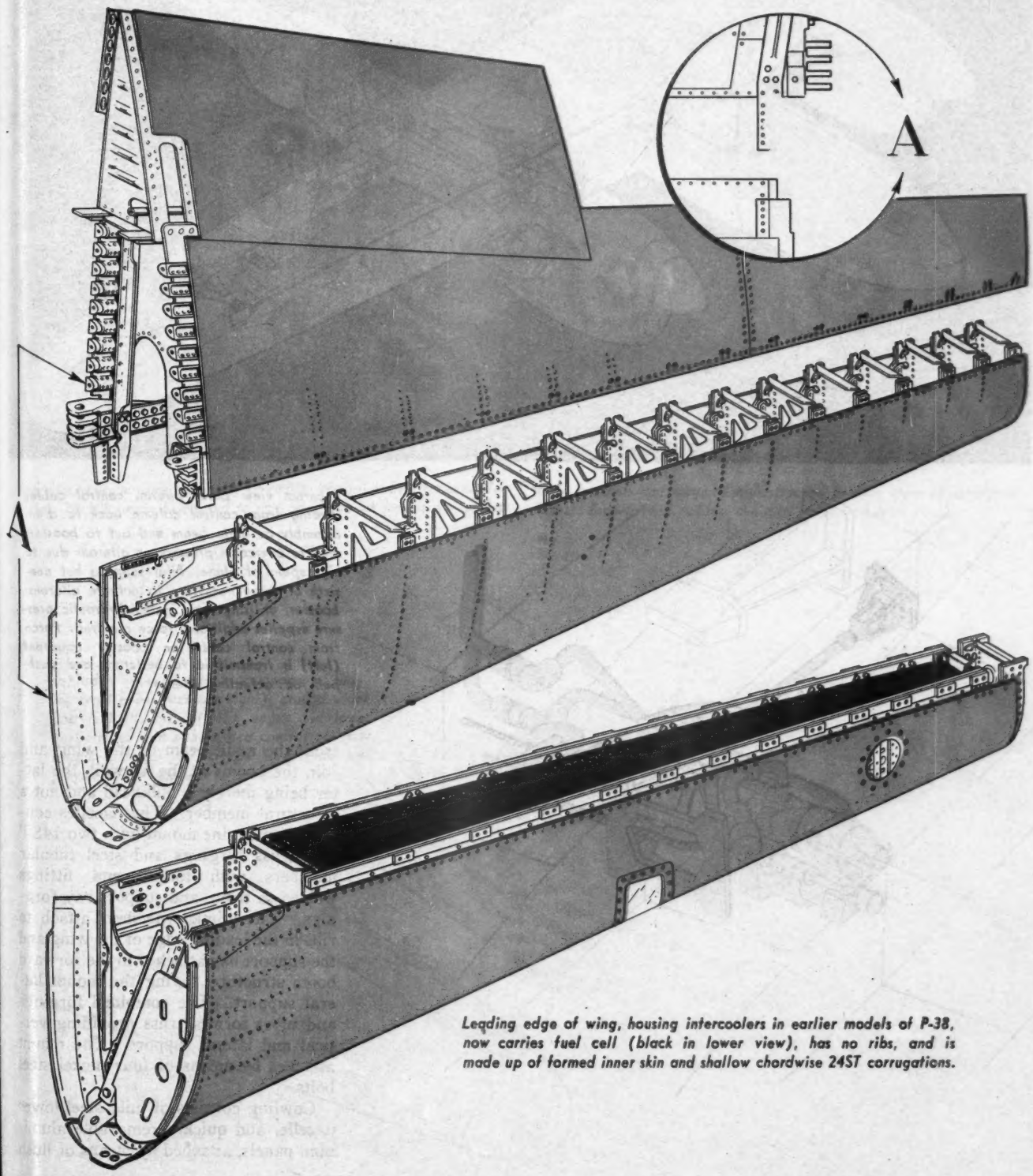
One of the performance characteristics of the *Lightning*—for which the tail surfaces and virtually all other parts of the airplane have taken quite a beating from critics—was its apparent inability to roll as rapidly as fighter tactics required. Here again the high speed with its resultant pressure on the ailerons, necessitated another first, the aileron booster.

This system uses the main hydraulic pressure to supplement the pilot's pressure on the aileron control surfaces. Operation is such that the pilot maintains the feel of the control but supplies only 17 percent of the force required to actuate the ailerons, servo action supplying the remainder.

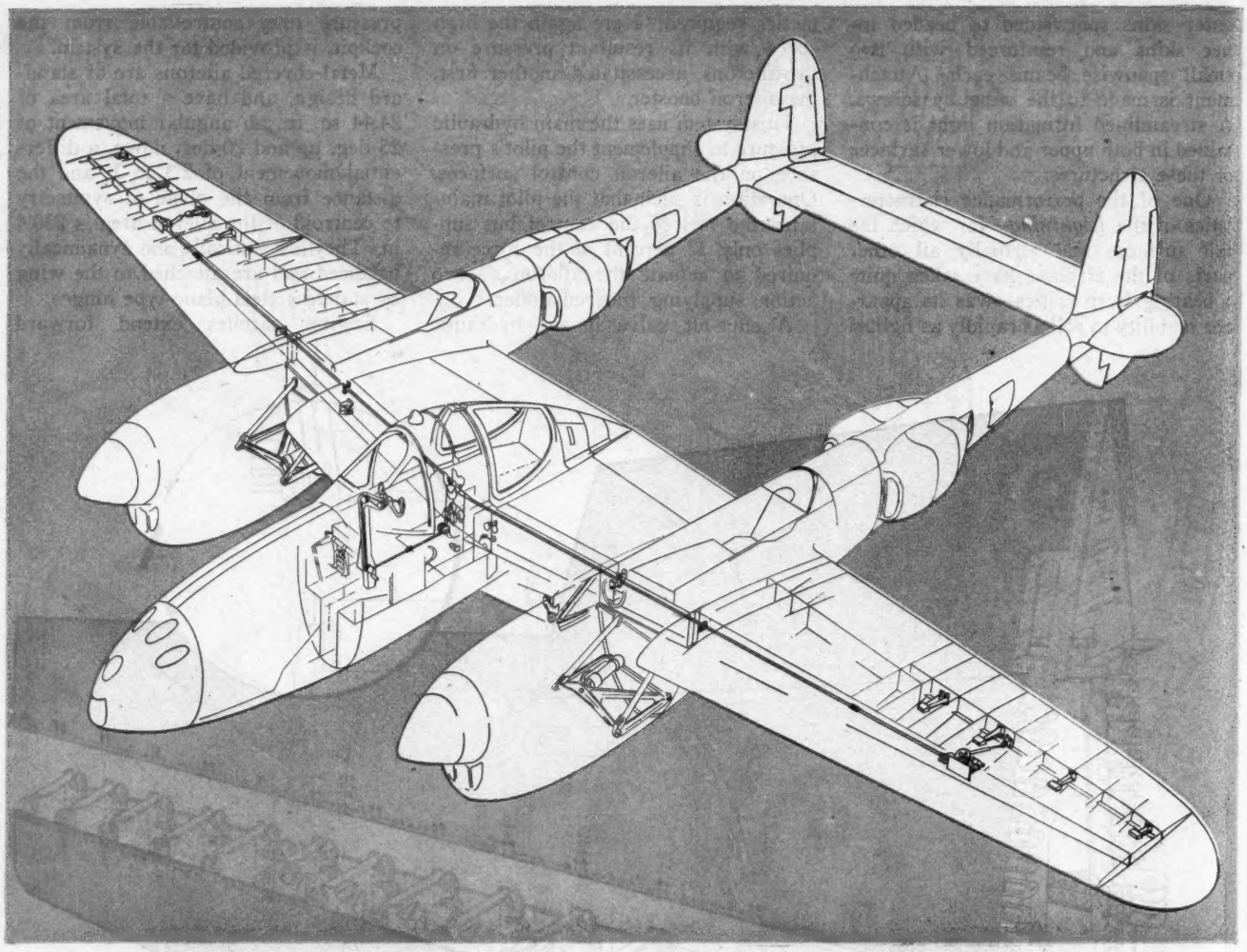
A shut-off valve in the hydraulic pressure line, controllable from the cockpit, is provided for the system.

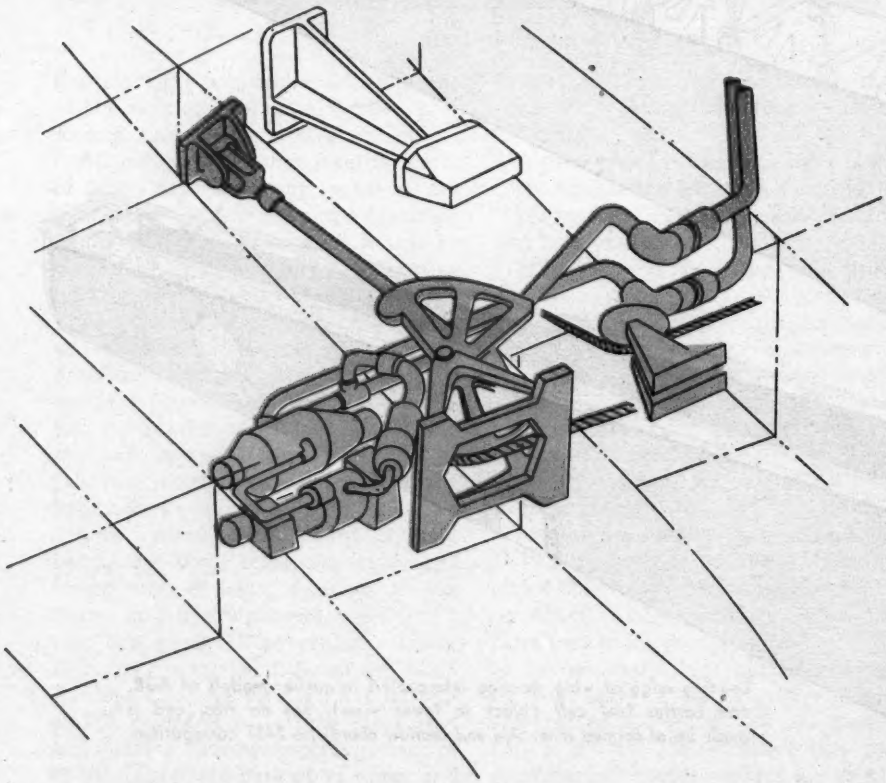
Metal-covered ailerons are of standard design, and have a total area of 24.44 sq. ft., an angular movement of 25 deg. up and 20 deg. down, a differential movement of 2.3 to 1, and the distance from the plane of symmetry to centroid of the aileron area is 230.4 in. They are statically and dynamically balanced and are attached to the wing by stainless steel piano-type hinges.

Engine nacelles extend forward



Leading edge of wing, housing intercoolers in earlier models of P-38, now carries fuel cell (black in lower view), has no ribs, and is made up of formed inner skin and shallow chordwise 24ST corrugations.

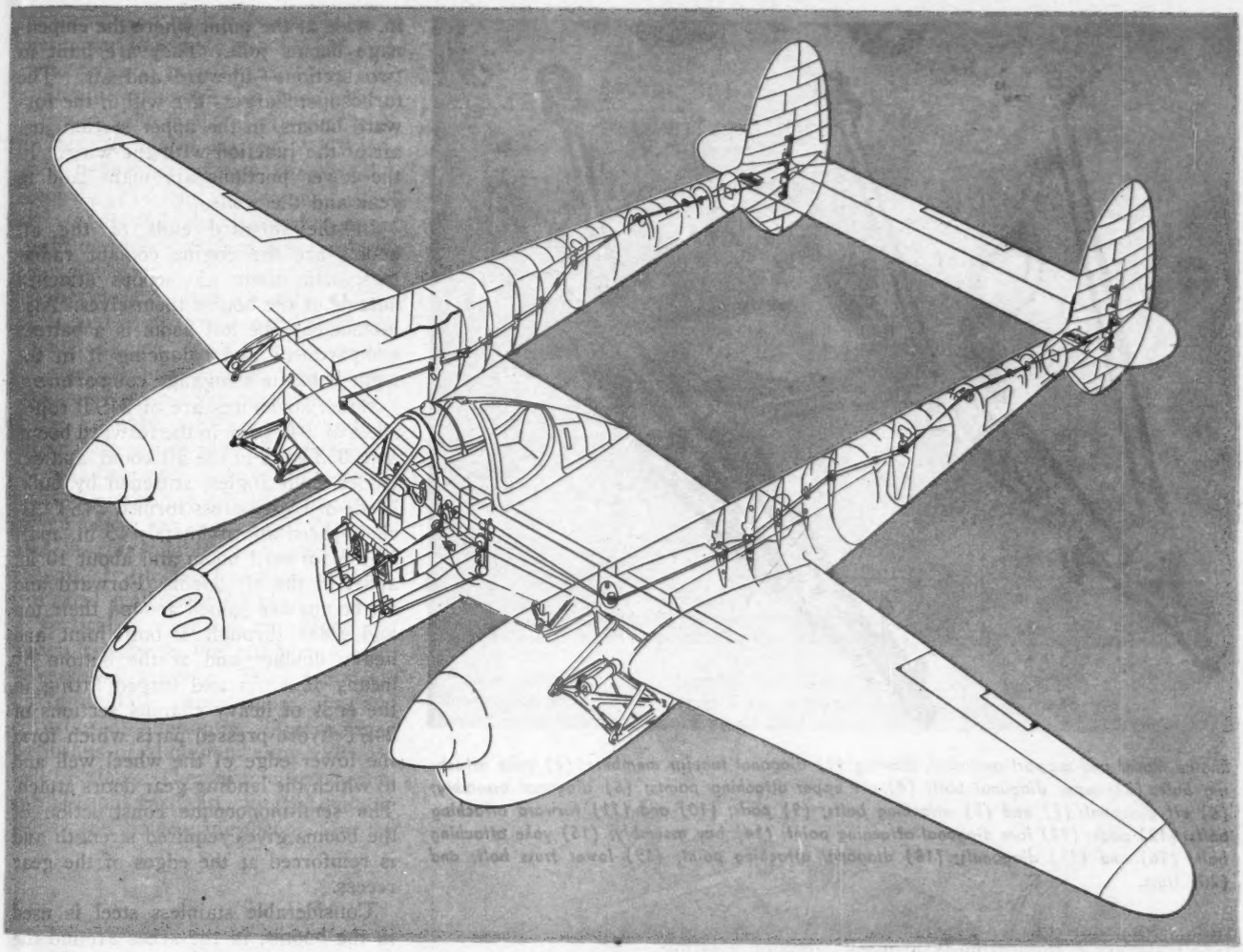




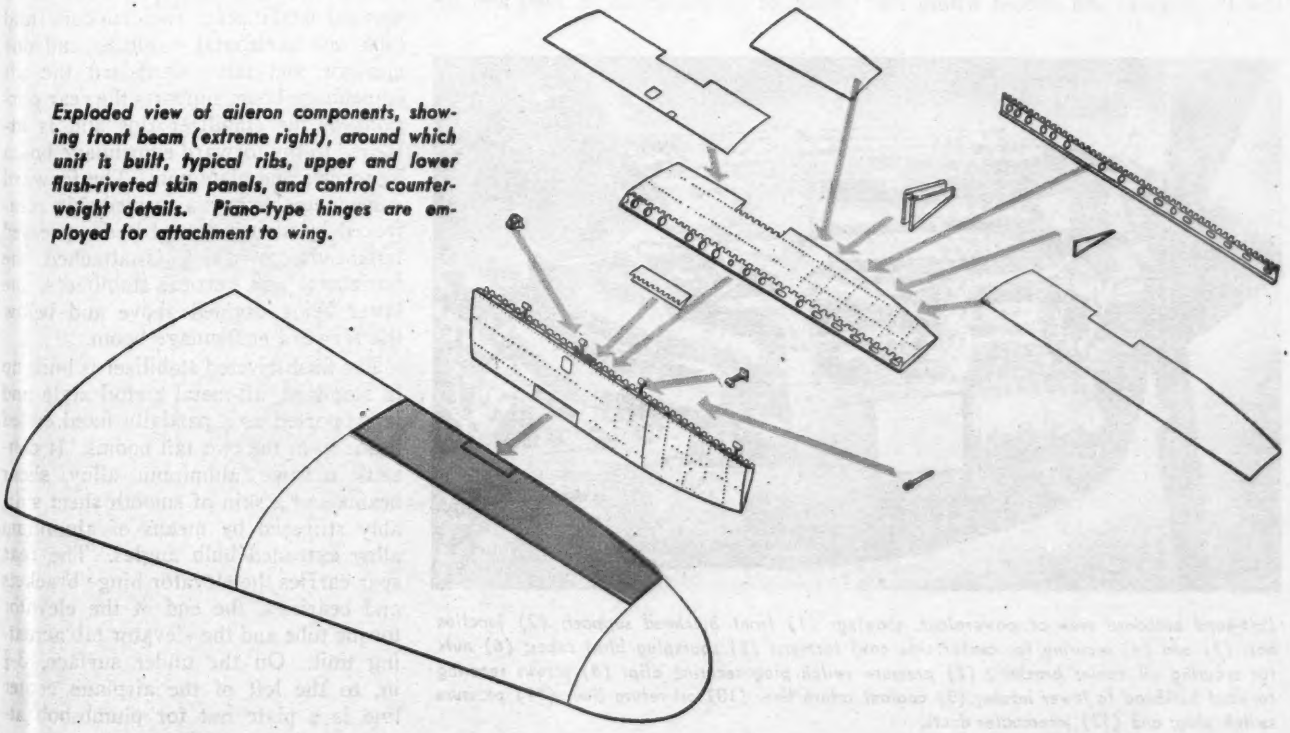
Phantom view shows aileron control cables leading from control column back to drum assembly on main beam and out to boosters used to overcome pressure on ailerons due to high speed of plane. Pilot supplies but one-sixth of force necessary to actuate ailerons; booster, utilizing main system hydraulic pressure supplies additional force required. Force from control cable on booster quadrant (left) is transmitted to bellcrank and push-pull rod, actuating aileron.

from the main beam of the wing and join the booms at the firewall, the latter being merely a bulkhead and not a structural member. The nacelles consist of an engine mount with two 14ST side truss forgings and steel tubular members with forged end fittings welded to them, and support bay forgings. The tubular members attach to ribs in the leading edge of the wing and the support bay attaches to the forward boom structure, giving the mount lateral support. The combined forgings and tubes form a truss providing vertical and lateral support. The mount attaches by means of four nickel steel bolts.

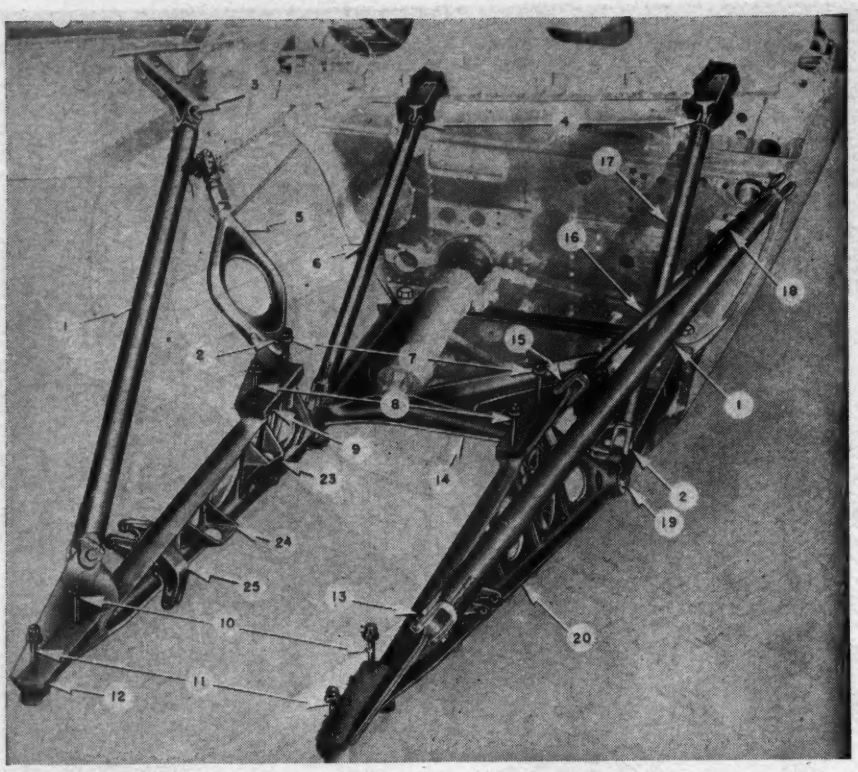
Cowling consists of mild steel lower nacelle, and quickly removable aluminum panels, attached by means of flush



Phantom view showing continuity of rudder control cables from rudder pedals back to main beam, out to and back through booms, to rudder hinge brackets and torque tubes attached to rear spars of stabilizers. Tabs in flush-riveted rudders are also controlled from cockpit.



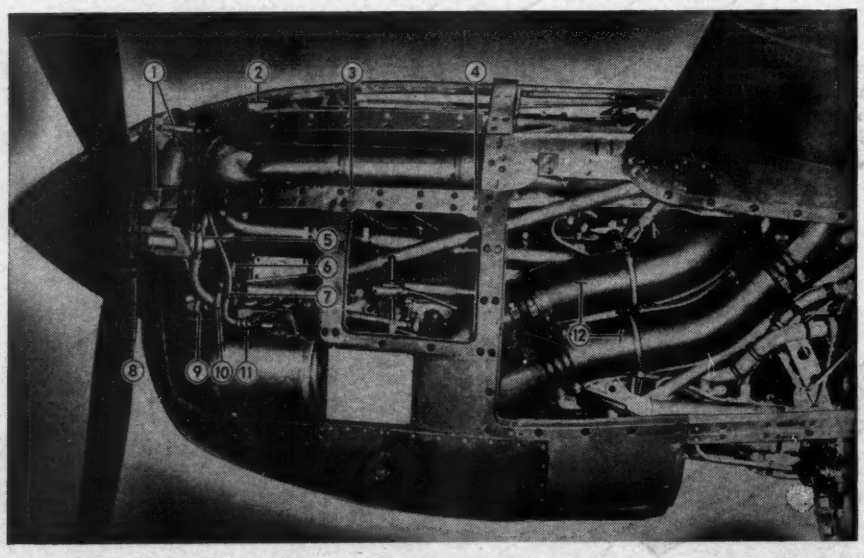
Exploded view of aileron components, showing front beam (extreme right), around which unit is built, typical ribs, upper and lower flush-riveted skin panels, and control counterweight details. Piano-type hinges are employed for attachment to wing.



Engine mount and support assembly, showing (1) diagonal tubular members; (2) yoke attaching bolt; (3) upper diagonal bolt; (4) aft upper attaching points; (5) diagonal assembly; (6) aft diagonal; (7) and (8) attaching bolts; (9) pads; (10) and (11) forward attaching bolts; (12) pads; (13) fore diagonal attaching point; (14) bay assembly; (15) yoke attaching bolt; (16) and (17) diagonals; (18) diagonal attaching point; (19) lower truss bolt; and (20) truss.

type fasteners to supporting framework of pressed aluminum alloy and steel attached to the engine itself and to the mount. Bottom skin of the cowling and sections around the exhaust manifolds are of steel. Intercoolers are below the engines and housed within the engine cowling.

Booms begin at the firewall and extend aft to support the empennage, tapering from 47⅜ in. in height and 38.63 in. in width at their deepest section just aft of the trailing edge of the wing, to an ellipse, 13 in. high and 10 in. wide at the point where the empennage booms join. They are built in two sections—forward and aft. The turbosuperchargers are within the forward booms, in the upper section just aft of the junction with the wing. In the lower portions are main landing gear and the wells.



Left-hand outboard view of powerplant, showing: (1) front bulkhead support; (2) junction box; (3) and (4) securing for center side cowl formers; (5) sparkplug blast tubes; (6) nuts for securing oil cooler brackets; (7) pressure switch plug securing clip; (8) screws securing forward bulkhead to lower intake; (9) coolant return line; (10) oil return line; (11) pressure switch plug; and (12) intercooler ducts.

In the forward ends of the aft booms are the engine coolant radiators, with their air scoops attached outside of the booms themselves. Also included in the left boom is a battery compartment and balancing it in the right boom is a luggage compartment.

Boom structures are of 24ST rolled sheet of .040 gage in the forward boom, and .032 gage in the aft boom, and extruded bulb angles, stiffened by bulkheads of hydro-press formed 24ST Alclad spaced approximately 15 in. apart in the forward boom and about 10 in. apart in the aft boom. Forward and aft booms are joined around their top and sides through a butt joint and heavy doubler and at the bottom by means of a pin and forged fitting in the ends of heavy channel sections of 24ST hydro-pressed parts which form the lower edge of the wheel well and to which the landing gear doors attach. The semi-monocoque construction of the booms gives required strength and is reinforced at the edges of the gear recess.

Considerable stainless steel is used in the booms, in the areas around the superchargers and it was to fabricate this that the manufacturing divisions were forced to do considerable research and other pioneering.

The empennage consists of two booms—forming the tail cone—two vertical stabilizers, two rudders and tabs, one horizontal stabilizer and one elevator and tab. Outboard the aft empennage boom supports the rear portions of the stabilizer tips and is attached to the forward empennage boom by screws and plate nuts. The forward empennage boom is a formed skin reinforced by stringers and hydro-pressed bulkheads, to which is attached the horizontal and vertical stabilizers, the latter being divided above and below the forward empennage boom.

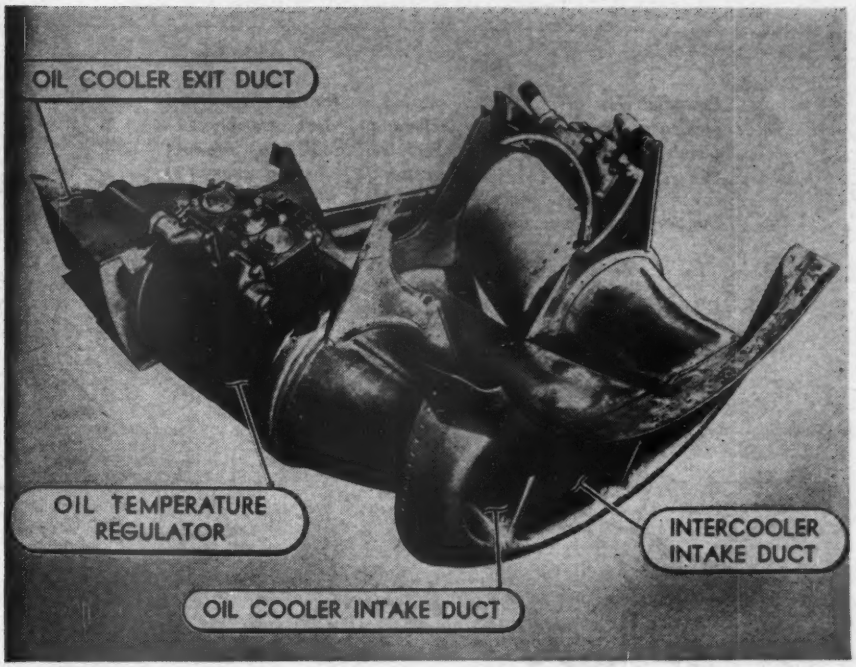
The flush-riveted stabilizer is built up in standard, all-metal airfoil style and is supported as a partially fixed ended beam from the two tail booms. It consists of two aluminum alloy shear beams and a skin of smooth sheet suitably stiffened by means of aluminum alloy extruded bulb angles. The rear spar carries the elevator hinge brackets and bearings, the end of the elevator torque tube and the elevator tab actuating unit. On the under surface, 3¼ in. to the left of the airplane center line is a plate nut for plumb-bob at-

tachment, and on the leading edge at the center line is an eye for alternate radio antenna attachment.

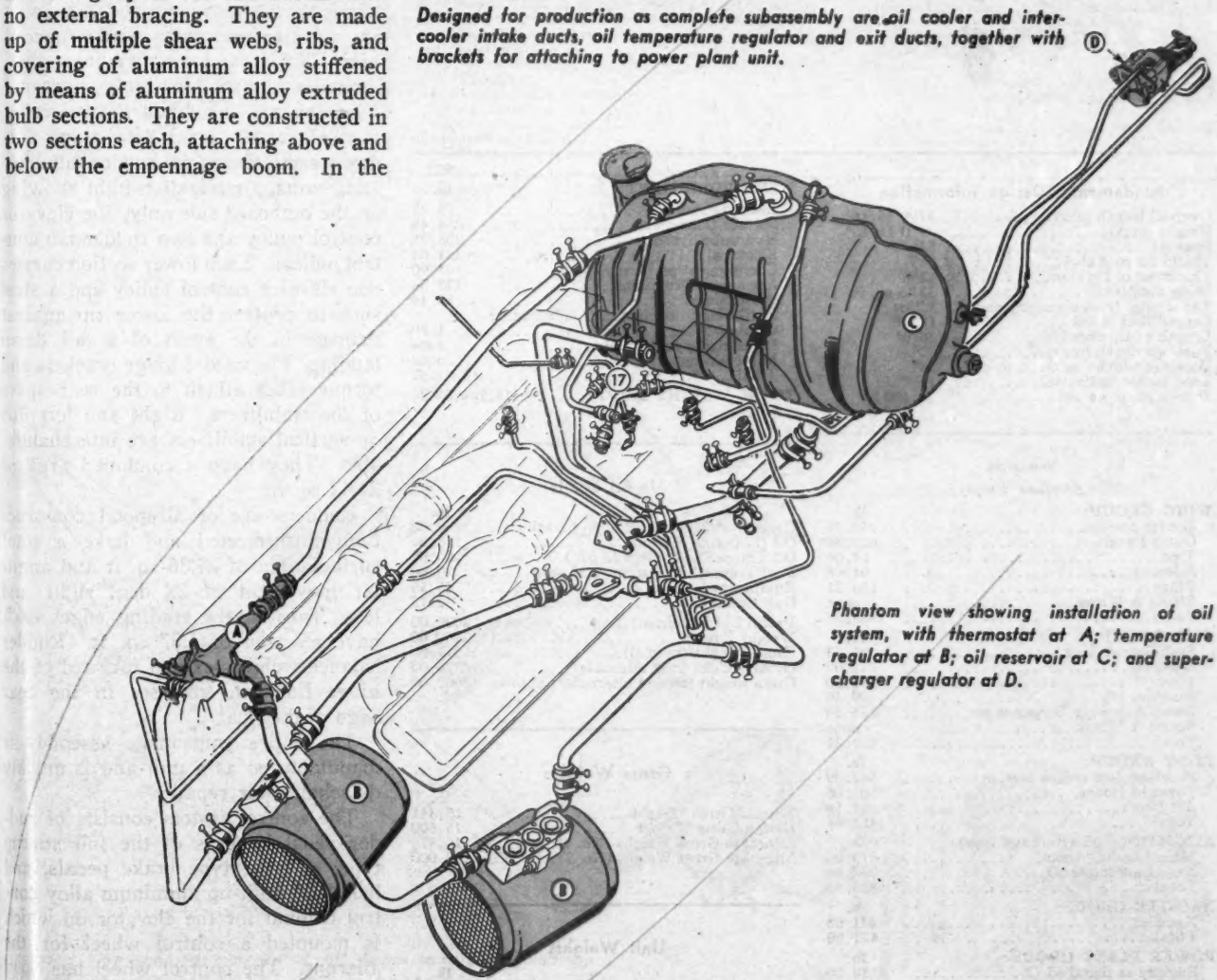
Stabilizer tips are also made up with a smooth aluminum alloy skin, flush-riveted to hydro-pressed 24ST ribs and channel strips, and attach to the empennage boom by means of 40 screws around the inboard contour. Right and left stabilizer tips are interchangeable.

The elevator has an area of 24.5 sq. ft. and angular movement of 23 deg. up and 8½ deg. down. It is statically balanced by four weights, one in each boom and two at the centerline. It is metal covered, flush-riveted and its internal structure is similar to that of the stabilizer and other control surface units. Its trim tab, placed at the plane of symmetry, has an area of 1.73 sq. ft., and is controllable from the pilot's cockpit. It attaches by means of stainless steel piano-type hinges.

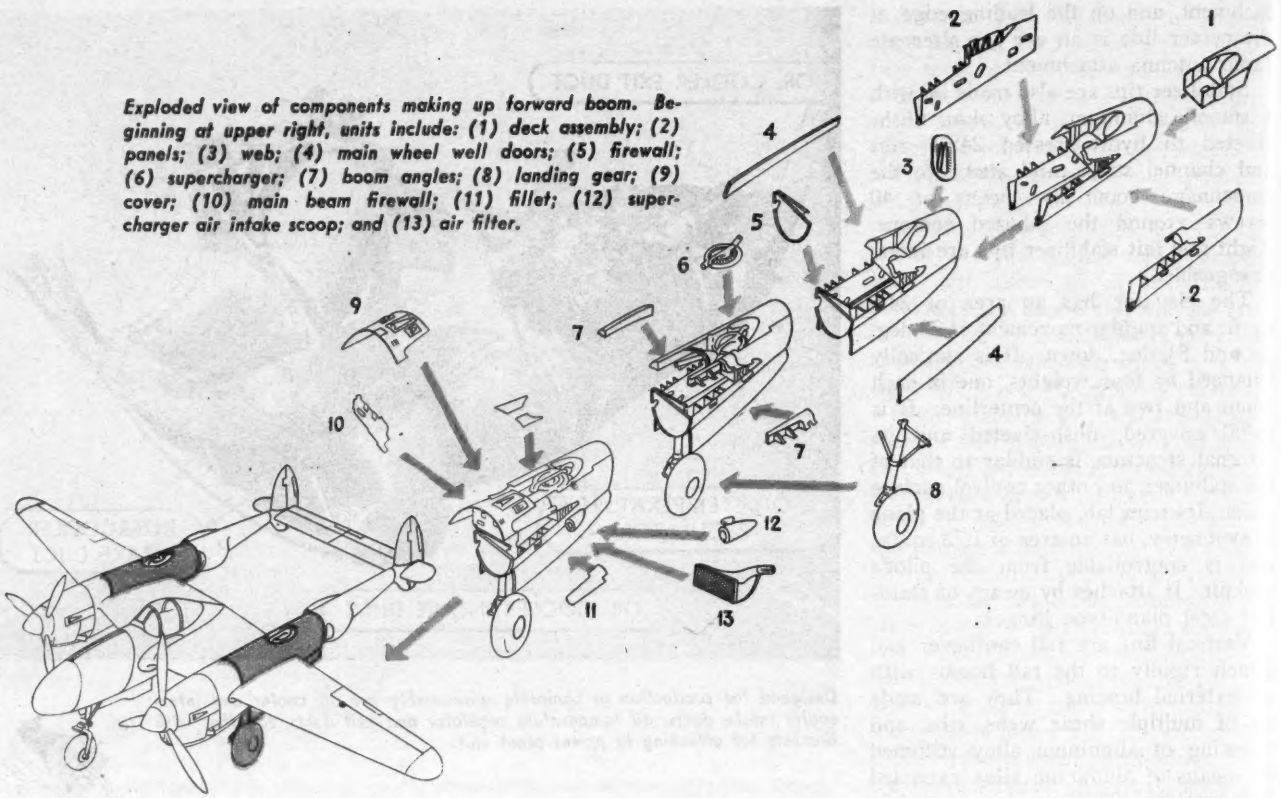
Vertical fins are full cantilever and attach rigidly to the tail booms with no external bracing. They are made up of multiple shear webs, ribs, and covering of aluminum alloy stiffened by means of aluminum alloy extruded bulb sections. They are constructed in two sections each, attaching above and below the empennage boom. In the



Designed for production as complete subassembly are oil cooler and intercooler intake ducts, oil temperature regulator and exit ducts, together with brackets for attaching to power plant unit.



Phantom view showing installation of oil system, with thermostat at A; temperature regulator at B; oil reservoir at C; and supercharger regulator at D.



Exploded view of components making up forward boom. Beginning at upper right, units include: (1) deck assembly; (2) panels; (3) web; (4) main wheel well doors; (5) firewall; (6) supercharger; (7) boom angles; (8) landing gear; (9) cover; (10) main beam firewall; (11) fillet; (12) supercharger air intake scoop; and (13) air filter.

Fundamental Design Information

Over-all length (max)	37' 9 15/16"
Height (max)	9' 9 11/16"
Span	52'
Thickness root chord	16%
Thickness of tip chord	12%
Wing area (net)	327.5 sq. ft.
Taper ratio (root chord/tip chord)	3.25:1
Length root chord	117.0"
Length of tip chord	36.0"
Fuselage depth (max)	72"
Fuselage width (max)	38"
Load factor (ultimate)	11.7
Design gross weight	15,500 lb.

Weights
(Airplane Empty)

	lb.
WING GROUP:	
Center Section	958.75
Outer Panels	612.84
Tips	14.00
Ailerons	91.68
Flaps	136.31
Struts & Wires	none
Total	1813.58
TAIL GROUP:	lb.
Stabilizer & Tips	97.33
Elevator	113.09
Fins (2)	52.20
Rudders (2)	99.49
Boom Assembly Empennage	55.10
Struts & Wires	none
Total	417.21
BODY GROUP:	lb.
Fuselage, less engine section	667.39
Forward Boom	605.06
Aft Boom	181.19
Total	1453.64
ALIGHTING GEAR (Land type):	lb.
Main Landing Gear	679.00
Nose Landing Gear	206.94
Total	885.94
NACELLE GROUP:	lb.
Nacelles	471.00
Total	471.00
POWER PLANT GROUP:	lb.
Engines as installed (2)	2730.00
Engine Accessories	297.30
Power Plant Controls	80.80
Propellers and Spinners (2)	827.32
Starting System	82.30
Supercharger System (incl. intercoolers, 130 lb.)	613.52
Cooling System	1065.10
Lubricating System	194.11

FIXED EQUIPMENT:	lb.
Instruments	73.22
Surface Controls	234.40
Hydraulic System	208.95
Electrical	321.08
Communicating (Army)	161.90
Armament Provisions	175.54
Furnishings	86.44
Anti-Icing equipment (defrosting tubes)	1.50
Pressurizing equipment	none
Miscellaneous	none
Total	1262.42
TOTAL WEIGHT EMPTY	**12,700.00 lb.**

Useful Loads

	lb.
Crew (1 at 200 lb., including parachute)	200.00
Oil (17 gal. at 7.5 lb.)	128.00
Oil Trapped in System (8 gal.)	60.00
Fuel Trapped in System (3.33 gal.)	20.00
Equipment	35.55
Gun Camera	2.75
Useful Load (normal)	over 2000.00
Weight Empty	12700.00
Gross Weight (normal)	15341.00
Gross Weight (first alternate)	16376.00
Gross weight (second alternate)	approx. 18000.00

Gross Weights

	lb.
Normal Gross Weight	15,341
Design Gross Weight	15,500
Alternate Gross Weight (No. 1)	16,376
Alternate Gross Weight (No. 2)	18,000

Unit Weights

	lb.
Wing Group (net area 327.5 sq. ft.) lb. per sq. ft.	5.54
Tail Group (net area 127.28 sq. ft.) lb. per sq. ft.	3.28
Weight of cooling system per normal hp. (hp. 2200)	0.48
Weight of lubricating system per gal. oil (26 gal.)	7.47

upper sections are the rudder tab actuating units, a navigation light showing on the outboard side only, one elevator control pulley and two rudder tab control pulleys. Each lower section carries one elevator control pulley and a steel shoe to protect the lower tip against damage in the event of a tail down landing. The rudder hinge brackets and torque tubes attach to the rear spars of the stabilizers. Right and left fins or vertical stabilizers are interchangeable. They have a combined area of 24.42 sq. ft.

Rudders are of all-metal construction, flush-riveted and have a total surface area of 21.36 sq. ft and angular movement of 28 deg. right and left. Tabs in the trailing edges each have an area of 1.37 sq. ft. Rudder balance weights extend forward of the hinge line into recesses in the rear edge of the fins.

The entire empennage assembly is manufactured as a unit and is quickly detachable for repair.

The control system consists of rudder pedal hangers of the full stirrup type, and toe type brake pedals, and half "Y" built-up aluminum alloy control column for the elevator on which is mounted a control wheel for the ailerons. The control wheel has open upper and lower segments and the upper corner of each of the two closed segments has one control button on the near side and one trigger type switch on the far side. Double $\frac{1}{8}$ in. diameter extra flexible preformed tinned carbon

steel control cables extend from the rudder pedals and control column back through the fuselage, diverging outward at the center section main beam to each boom.

One set of control cables for both elevator and rudders extends aft through each boom. Anti-friction type bearing pulleys and micarta or fiber guide blocks are used throughout the entire cable system. All control system bell cranks and masts for actuating the control system are mounted on anti-friction bearings and are housed entirely within the airplane contour. Inspection and service openings with flush-type cover plates are provided throughout.

Fuselage or gondola of the P-38 attaches to the center section at the plane of symmetry of the airplane and its line of juncture is covered by fillets. Its maximum height is 72 in. and its greatest width 38 in. It is fabricated of high strength aluminum alloy and is of stiffened monocoque construction, except where reinforcements for cut-outs renders this impractical. High strength aluminum-coated, aluminum alloy-formed bulkheads are spaced 15 in. apart and form the skeleton to which the smooth Alclad skin is flush-

Balance Factors

Gross Weight c.g. location, wheels up
Aft L.E.M.A.C. 24.53"–29.12% MAC
Gross Weight c.g. location, wheels down:
Aft L.E.M.A.C. 21.81"–25.89% MAC
Normal forward position of c.g. possible in flight:
Aft L.E.M.A.C. 20.61"–24.46% MAC
Normal rearward position of c.g. possible in flight:
Aft L.E.M.A.C. 26.80"–31.81% MAC

Design Details

WING GROUP:

Wing area	327.5 sq. ft.
Span	52 ft. 0 in.
Root Chord	117.0 in.
Tip Chord....(extreme)	36.0 in
Taper Ratio	3.25:1
Incidence 2 deg. at root.	0 at Sta. 289
Dihedral (L.E.)	5 deg. 40 min.
Sweepback (L.E.)	5 deg. 11 min. 30 sec.
Maximum rib spacing	54 in.
Shear web location:	
Front	10% chord
Rear	70% chord
Spar Location	35% chord
Stagger at lower wing root	not applicable
Gap at lower wing root	not applicable
Aspect Ratio	8.256
Decalage	not applicable
Mean Aerodynamic Chord:	
Length	84.25 in.
Location relative to L. E. Root Chord:	
Horizontal	11.46" Aft
Vertical	12.50" Above
Wing Construction	Full cantilever

CONTROL SURFACES

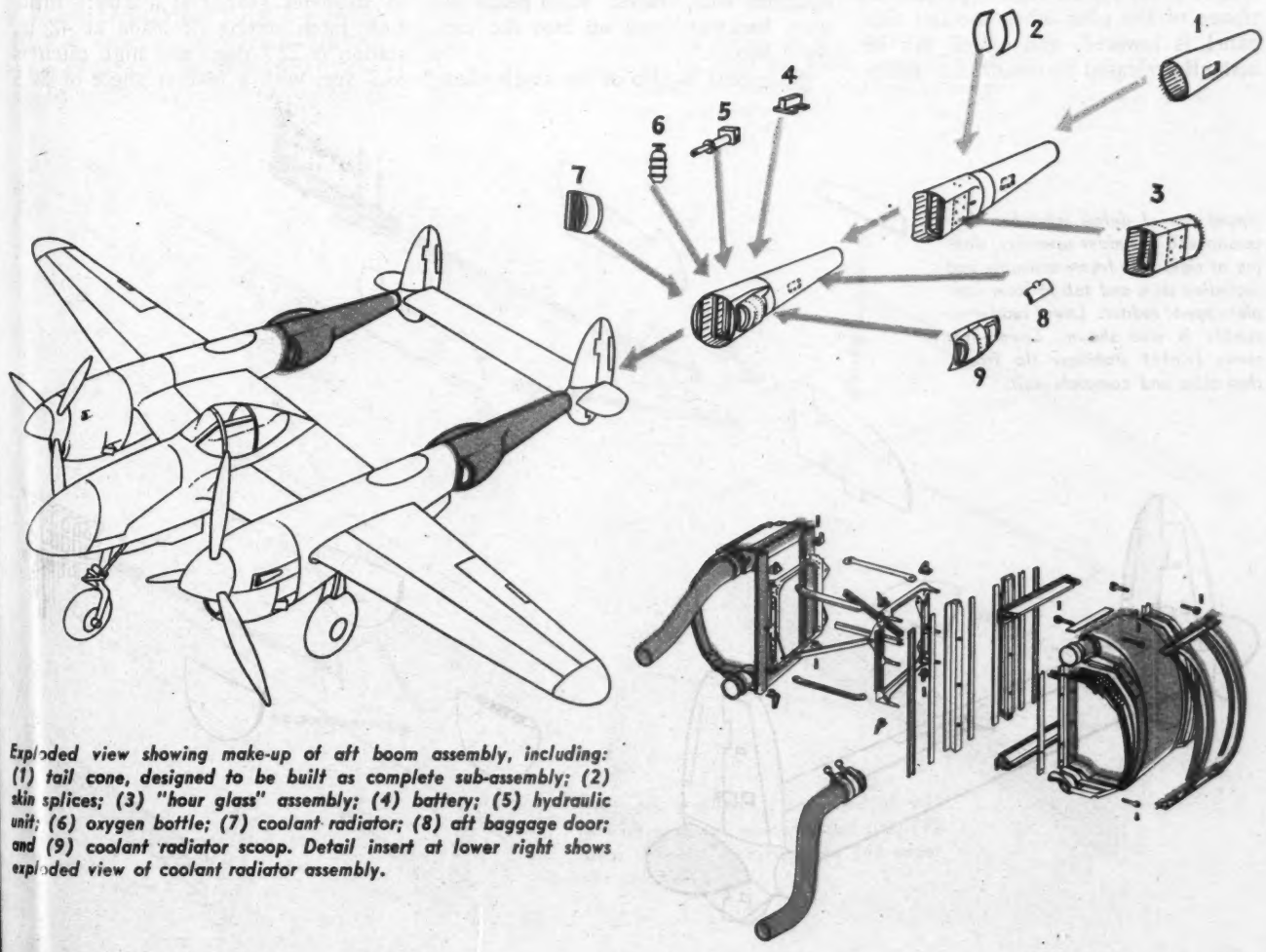
Ailerons (2):	
Area....12.22 sq. ft. each side (24.44 sq. ft. total)	
Angular movement...Up 25 deg.	Down 20 deg.
Distance from place of symmetry to centroid of aileron area	230.4 in.
Type of Balance: Counterweights within wing structure.	
Horizontal Tail Surfaces:	
Area: (total)	78.5 sq. ft.
Span	21 ft. 9 in.
Maximum Chord	45 in.(uniform)
Distance from gross weight c.g. wheels up to 1/3 max chord point	257.54 in. 305.69% M.A.C.
Stabilizer:	
Area	54.0 sq. ft.
Normal setting: (relative to thrust)	0 deg.
Angular movement	none
Elevator:	
Area	24.5 sq. ft.
Angular movement....Up 23 deg., down 8½ deg.	
Type of balance: Completely statically balanced by three weights, one in each boom and one on elevator structure at centerline of airplane.	
Tabs:	
Area	1.73 sq. ft.
Vertical Tail Surfaces:	
Fins: (2)	
Area (Each side, 13.71 sq. ft.)	27.42 sq. ft.
Normal Setting: (to path of flight)	0 deg.
Angular movement	none
Rudders: (2)	
Area: (Each side 10.68 sq. ft.)	21.36 sq. ft.
Angular movement	Right, 28 deg. Left, 28 deg.
Type of Balance: Dynamically and statically about their respective hinge lines.	
Tabs:	
Area: (Each)	1.37 sq. ft.
Lift and Drag Increasing Devices:	
Type	Fowler
Area	40 sq. ft.

BODY GROUP:

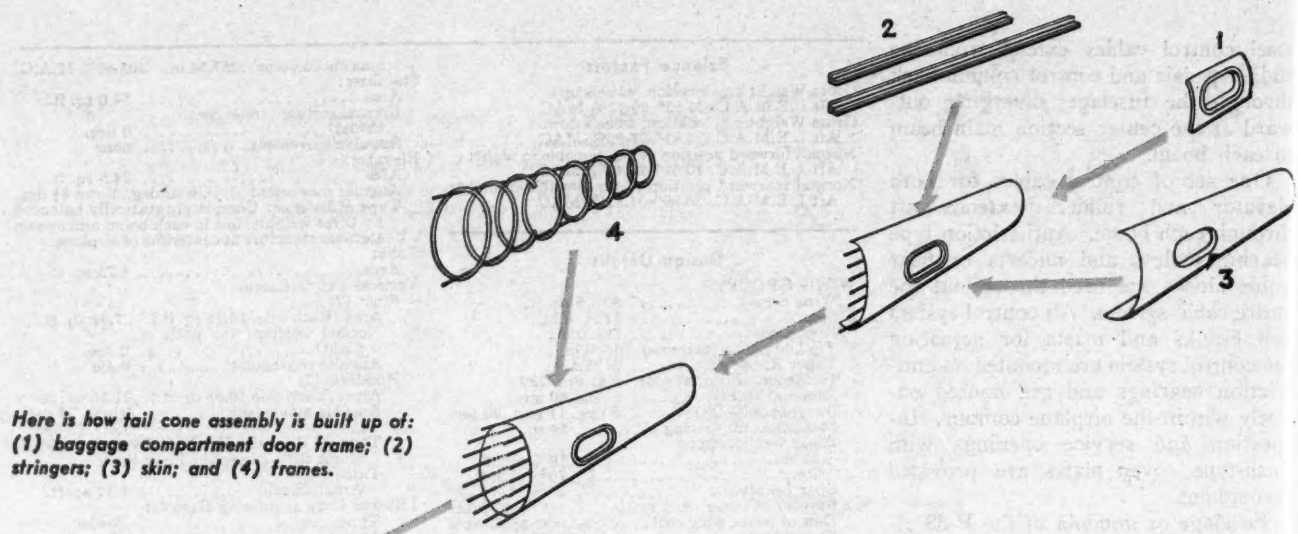
Fuselage:	
Height: (Maximum cross section)	72 in.
Width: (Maximum cross section)	38 in.

ALIGHTING GEAR:

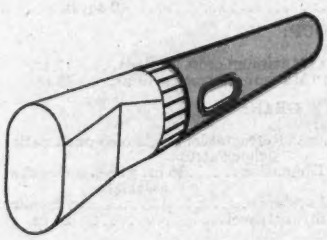
Main Gear:	
Type	Retractable, single oleo-pneumatic shock strut
Major Dimension	36 in. wheel and brake assembly
Control system	hydraulic
Shock Strut Travel	10 in.
Nose Gear:	
Type	Retractable, single oleo-pneumatic shock strut, and half type wheel fork.
Major Dimension	27 in. wheel assembly
Control System	hydraulic
Shock Strut Travel	12 in.



Exploded view showing make-up of aft boom assembly, including: (1) tail cone, designed to be built as complete sub-assembly; (2) skin splices; (3) "hour glass" assembly; (4) battery; (5) hydraulic unit; (6) oxygen bottle; (7) coolant radiator; (8) aft baggage door; and (9) coolant radiator scoop. Detail insert at lower right shows exploded view of coolant radiator assembly.



Here is how tail cone assembly is built up of: (1) baggage compartment door frame; (2) stringers; (3) skin; and (4) frames.



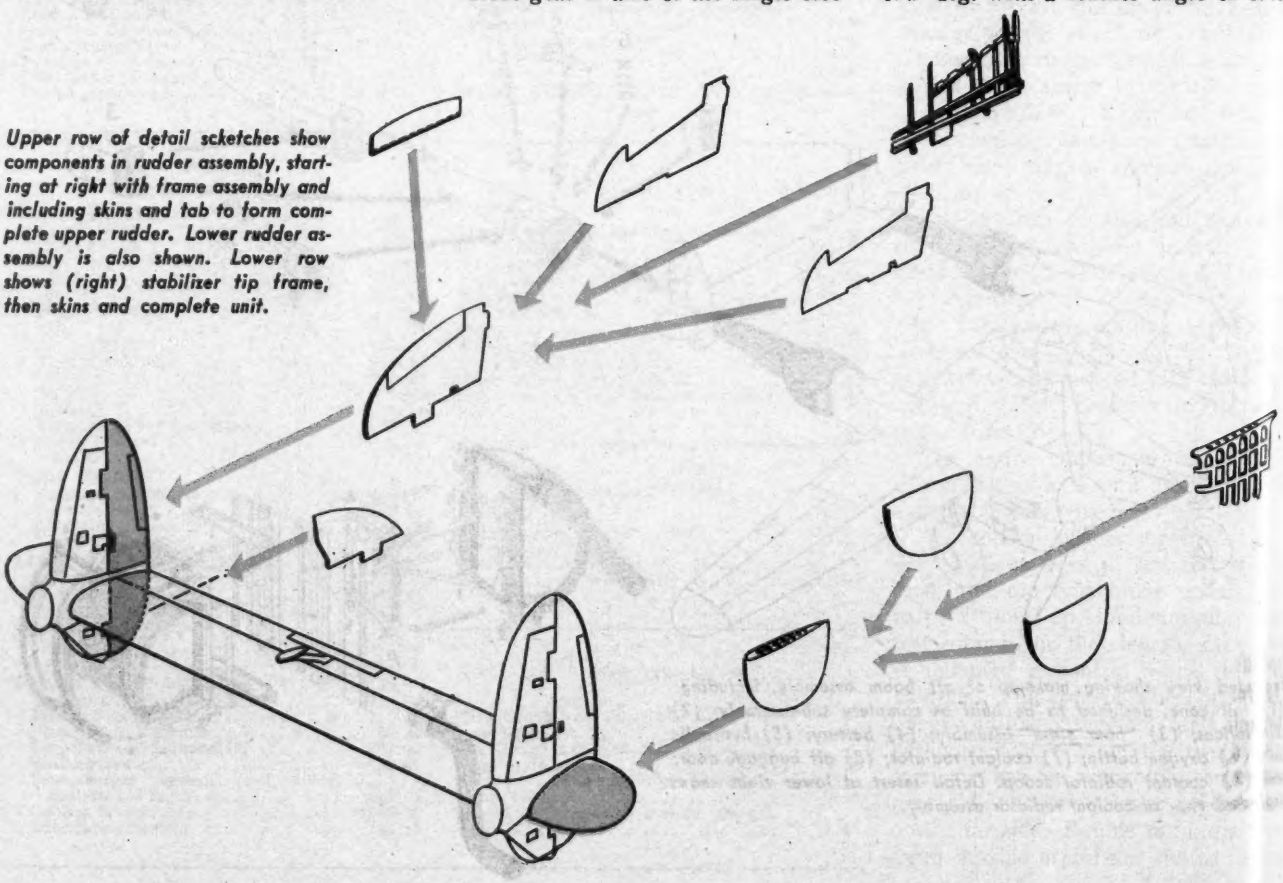
riveted. Cockpit enclosure incorporates side panels which may be lowered by the pilot, a top center transparent panel hinged at the top aft edge to permit entrance of the pilot when the left side panel is lowered, and which can be instantly released by means of a quick-release mechanism. Side panels can be opened or closed on the ground or in flight at reduced speed and may be locked in the open, closed or any intermediate position. Center panel of the front windshield is of bullet-proof glass.

The *Lightning's* tricycle landing gear is fully retractable with automatically opening and closing wheel well doors. The main gear has single oleo-pneumatic shock struts with a 10 in. travel, and is hydraulically operated. Wheels are 36 in. in diameter and are equipped with brakes. Main gears retract backward and up into the forward booms.

Nose gear is also of the single oleo-pneumatic shock strut type with a half type wheel fork. It is hydraulic and has a shock strut travel of 12 in. The nose wheel diameter is 27 in. Retraction is backward and up into a well in the fuselage.

Current P-38's are equipped with turbosupercharged 12 cylinder liquid-cooled V-1710 Allisons with a military and takeoff rating of 1,520 hp. to 27,000 ft. at 3,000 rpm. They are equipped with three-blade full feathering constant speed Curtiss electric propellers of 11 ft. 6 in. diameter geared at a 2.00:1 ratio. Low pitch setting of blade at 42 in. station is 22.7 deg., and high pitch is 57.7 deg. with a feather angle of 87.5

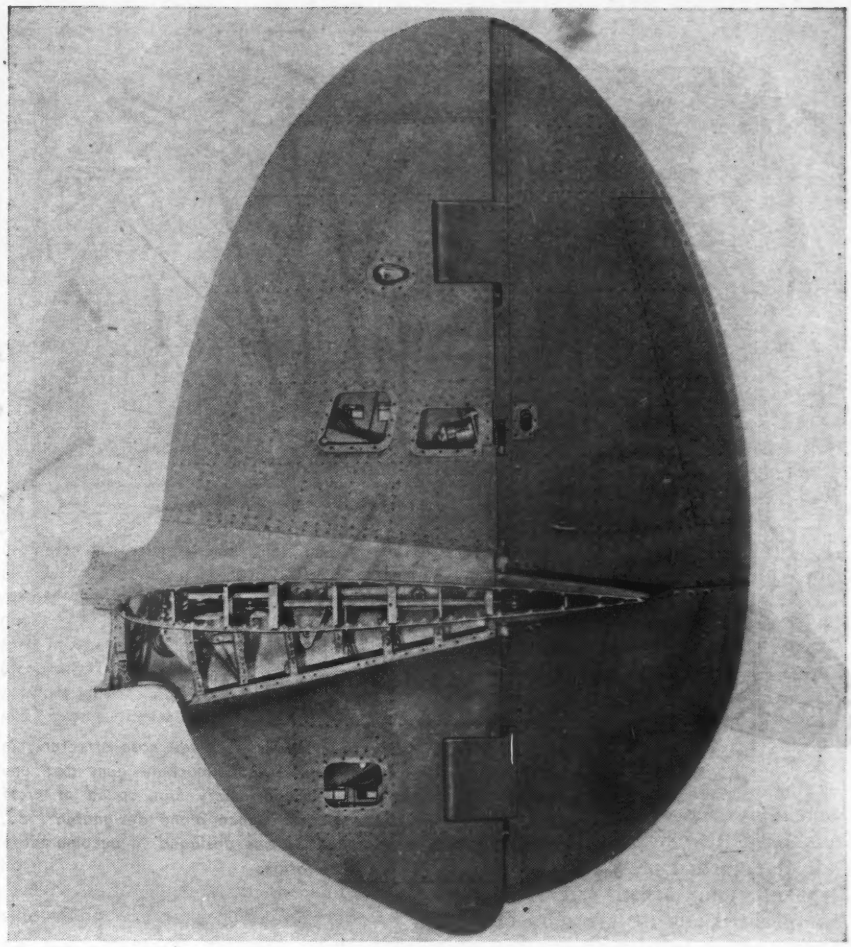
Upper row of detail sketches show components in rudder assembly, starting at right with frame assembly and including skins and tab to form complete upper rudder. Lower rudder assembly is also shown. Lower row shows (right) stabilizer tip frame, then skins and complete unit.



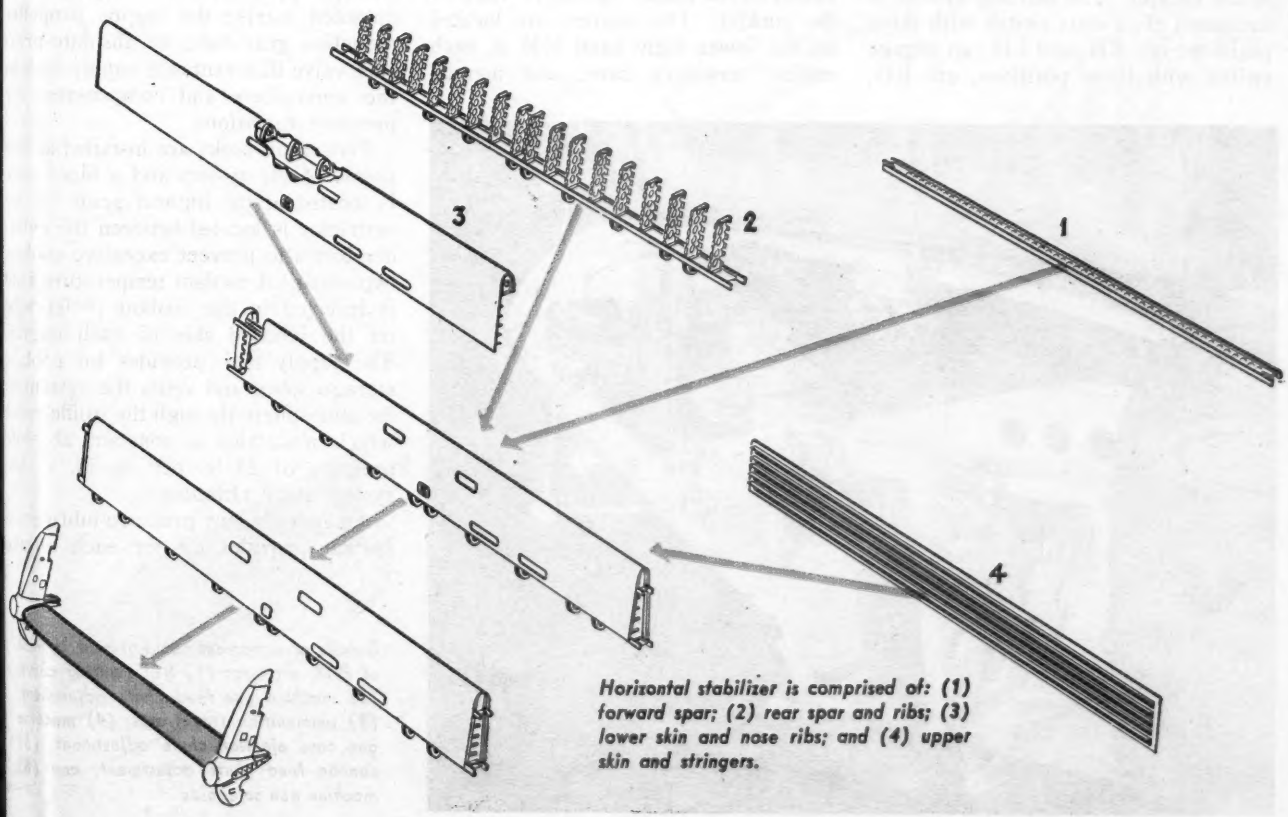
deg. Clearances are: to ground, level landing, approximately 16 in.; to fuselage, 9½ in.; to leading edge of wing, approximately 60 in.

Carburetors are Bendix-Stromberg PD-12K7, and differ from the conventional vented float chamber type in that the fuel system is closed from fuel pump to discharge nozzle. Fuel is delivered to the carburetor by the engine driven fuel pump at a pressure of 16 to 18 lb. per sq. in. Fuel delivered to the carburetor is metered in accordance with the mass air flow through the throat as registered by the venturi tube and automatic mixture control unit. Metered fuel then passes through the discharge tube to the discharge nozzle where it is sprayed into the air stream entering the internal supercharger.

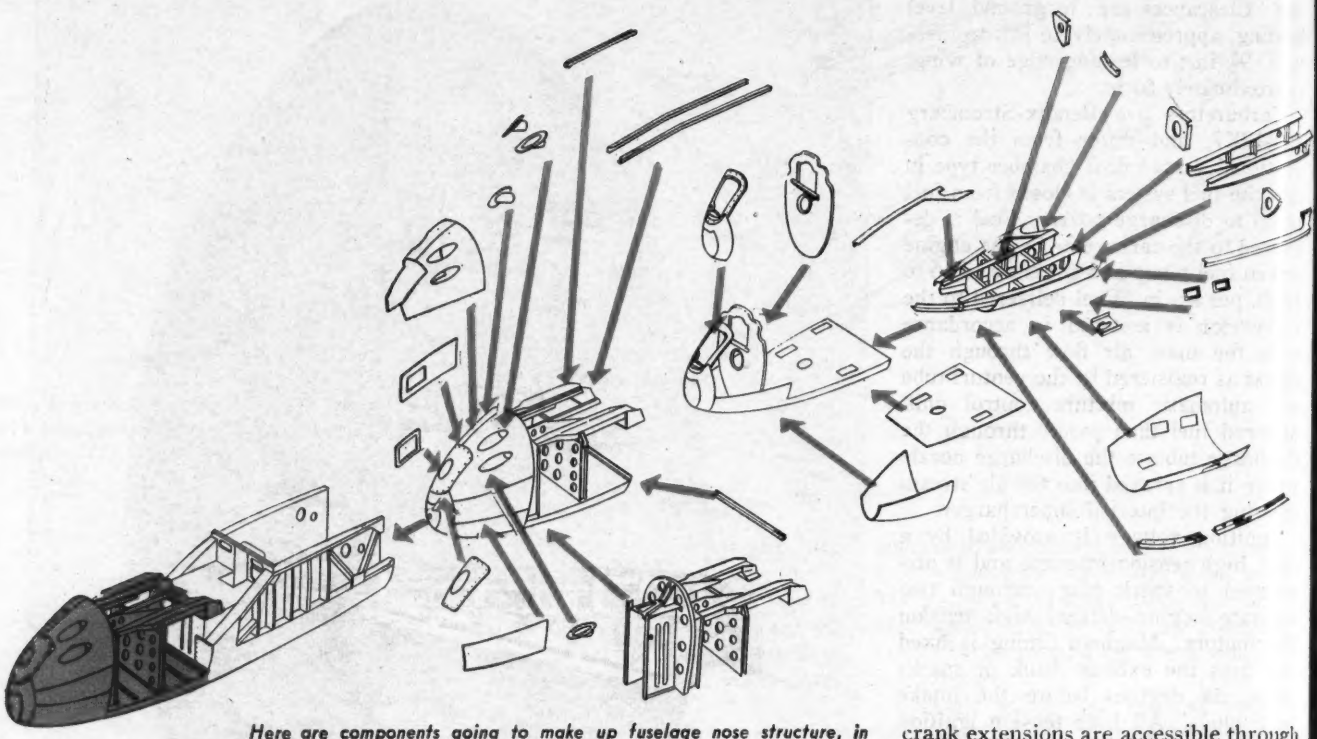
Ignition voltage is provided by a dual, high tension magneto and is distributed to spark plugs through two separate engine driven, high tension distributors. Magneto timing is fixed and fires the exhaust bank of sparkplugs six degrees before the intake bank plugs. All high tension ignition cables are shielded to prevent radio interference. Two sparkplugs are used for each cylinder, the exhaust plugs being cooled by a blast of cooling air conducted from the airplane slip stream through two aluminum alloy sparkplug cooling manifolds. Magnetoes are pressurized Bendix-Scintilla DFLN-6, providing double ignition from a single unit, and mounted by two bolts between the cylinder banks at the



Fin and rudder, showing profile of stabilizer tip, which attaches by screws. Fin-and-rudder unit attaches to tail cone by screws and plate nuts.



Horizontal stabilizer is comprised of: (1) forward spar; (2) rear spar and ribs; (3) lower skin and nose ribs; and (4) upper skin and stringers.



Here are components going to make up fuselage nose structure, in which P-38's heavy firepower—four 50-cal. machine guns and one 20mm. cannon—is concentrated. Exceptionally high speed of craft makes it invaluable as photo reconnaissance plane designated F-5B, in which this structure is replaced by one designed to accommodate any of four different camera installations.

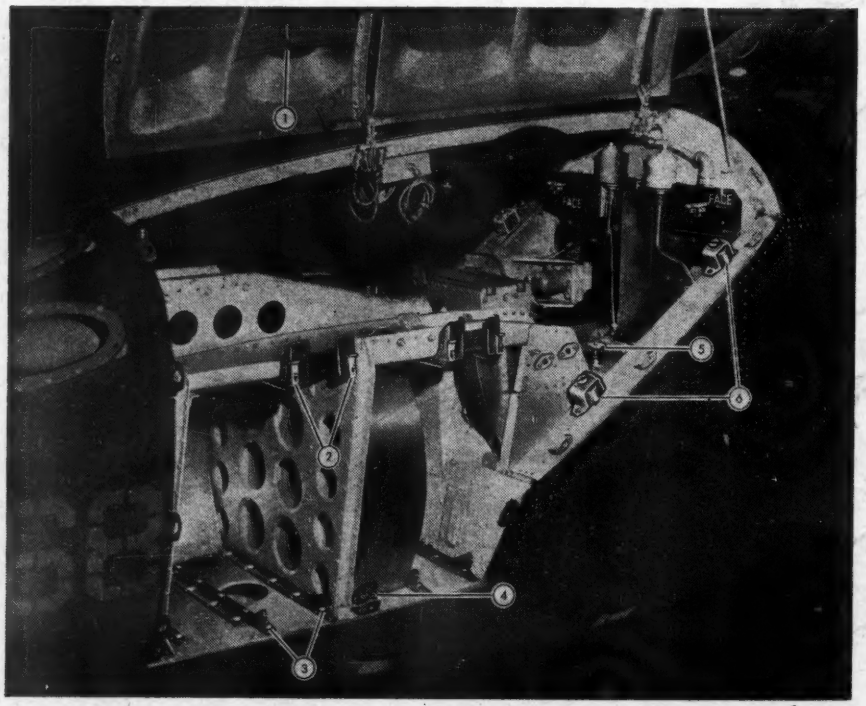
upper rear section of the P-38's engines.

Throttle, mixture and propeller governor controls are levers mounted in the side control stand at the pilot's left in the cockpit. The starting system is composed of: a start switch with three positions, off, RH, and LH; an engage switch with three positions, off, RH, and LH; two starters, with manual crank extensions; and two booster coils. Start and engage switches are located atop the main switch box adjacent to the master ignition switch in the cockpit. The starters are located on the lower right-hand side of each engine accessory case; and manual crank extensions are accessible through doors in the engine cowl panels.

Engines are cooled with ethylene glycol, Spe. AN-E-2, by separate systems, each consisting of a radiator mounted on each side of each aft boom, air scoops and exit flaps that control the flow of air through the radiators, a temperature-reactant four-way valve that automatically controls the exit flaps by hydraulic operation of an actuating cylinder, an engine-driven coolant pump, a coolant supply tank mounted astride the engine propeller reduction gear case, an absolute-pressure valve that vents the supply tank to the atmosphere and compensates for pressure variations.

Five drain cocks are installed at low points of the system and a bleed cock is located at the highest point. A tee restrictor is located between the cylinder banks to prevent excessive coolant bypassing. A coolant temperature bulb is inserted in the coolant outlet tube on the inboard side of each engine. The supply tank provides for coolant storage space and vents the system to the atmosphere through the sniffle valve which maintains a constant absolute pressure of 23 lb. per sq. in. in the system at all altitudes.

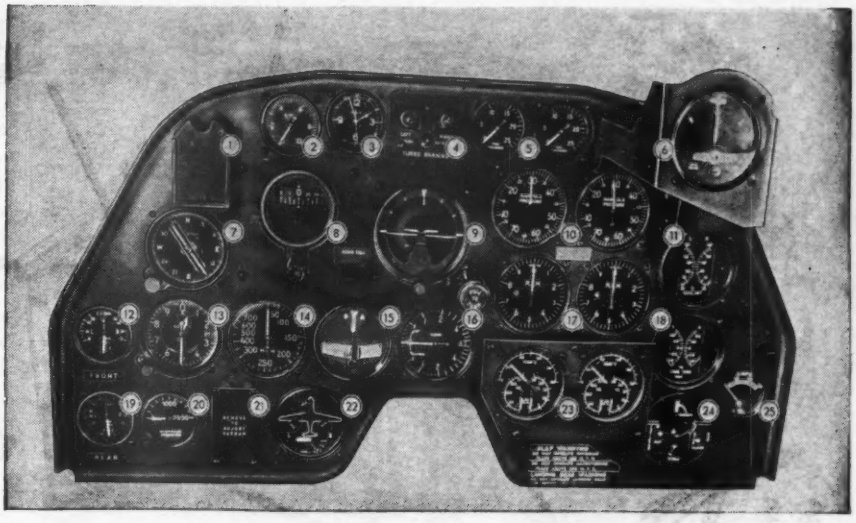
An independent pressure-lubrication system provides oil for each engine



Details of armament compartment in nose of P-38, showing: (1) gun sighting chart; (2) machine gun feed chute adjustment; (3) ammunition tray tracks; (4) machine gun case ejection chute adjustment; (5) cannon feed chute adjustment; and (6) machine gun solenoids.

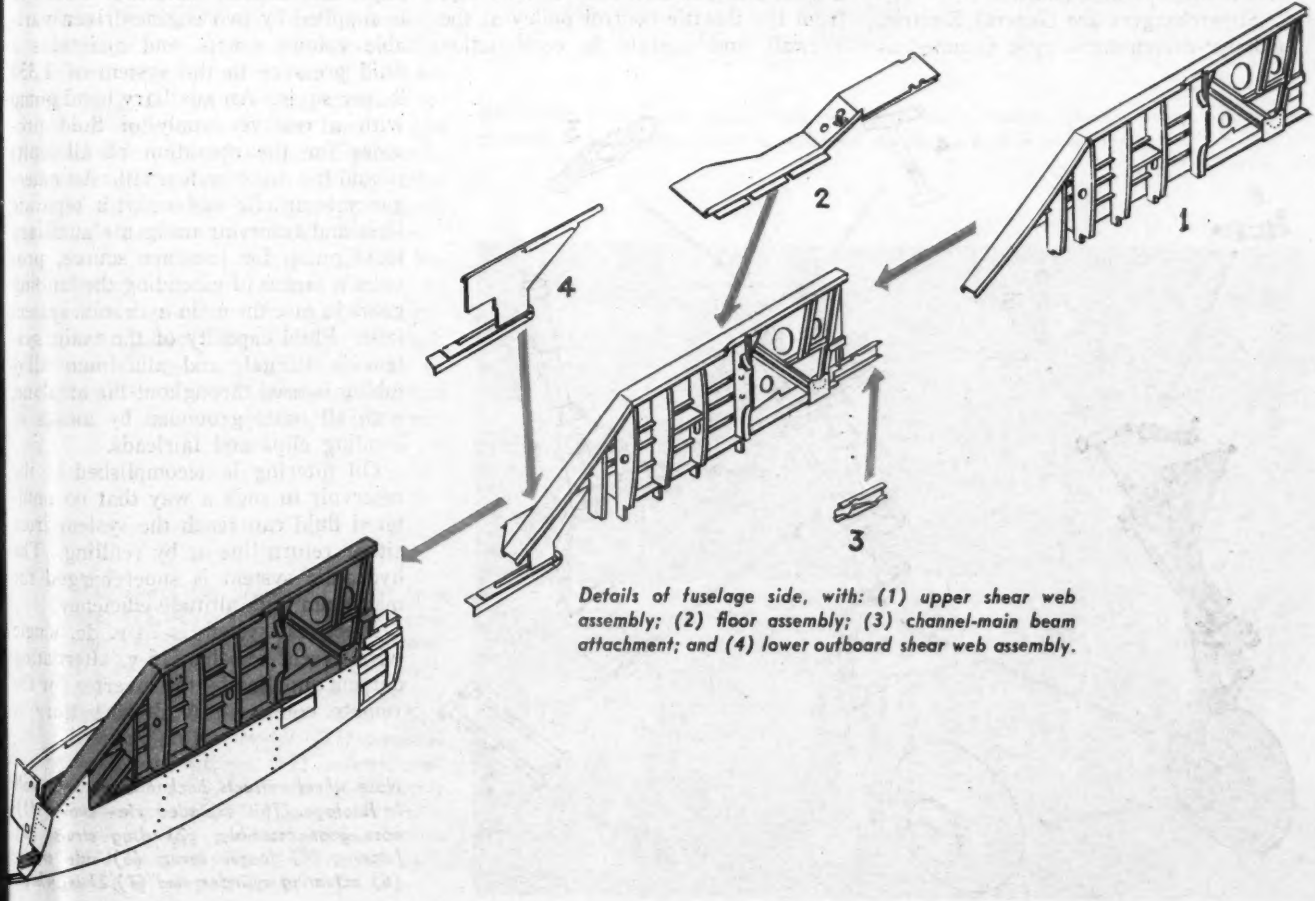
with oil gravity-fed from the reservoir tank through the hopper and the slide valve for inverted flight, to the pressure pump. Flow then is through a check valve which opens at 1 lb. pressure and closes when engine is stopped, to a strainer and thence to the engine. Three oil passages distribute oil from the strainer to the supercharger and all accessory drives contained in the accessories housing. From the strainer outlet, oil is also distributed to the moving parts of the engine. From the main scavenger pump outlet oil flows to the temperature regulator and when the oil is hot and does not exceed a pressure of 75 lb. per sq. in., it enters the regulator and flows through the core, out of the radiator, and back to the tank. Oil tanks are fabricated from 3SO aluminum alloy and are mounted on the front face of each firewall. Temperature regulation is automatically controlled by an electric actuator motor connected to the air duct exit flap.

Separate fuel systems supply each engine, with the two interconnected so that fuel from any tank except the outer wing tanks, is available for either engine. Three tanks supply each engine: (1) Main (2) reserve and (3) outer wing leading edge. In addition, droppable fuel tanks are carried under the center wing on both sides of the gondola and inboard of the engine nacelles. Electrically driven fuel boost pumps are mounted in the lower aft section of the fuselage and in the outer wing to assist the engine driven fuel pumps.

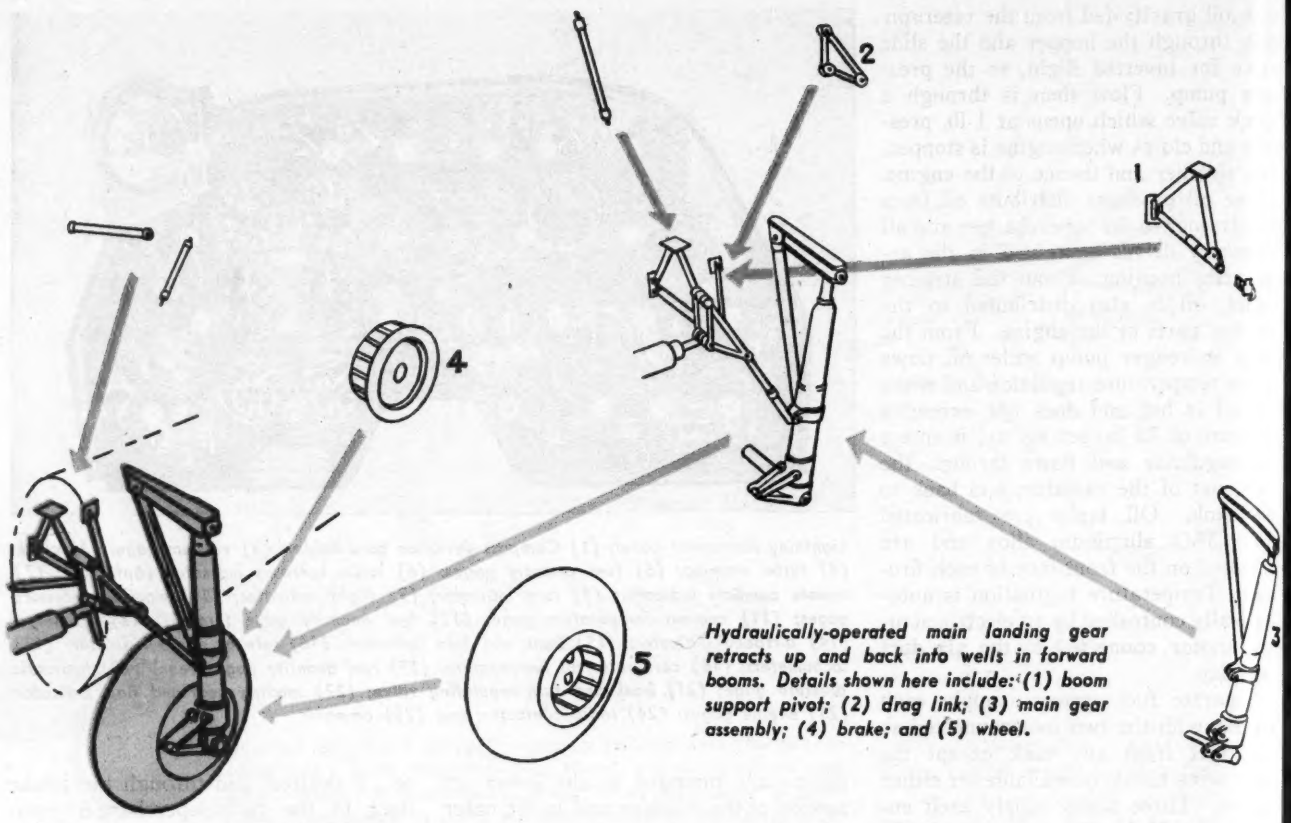


Lightning instrument panel: (1) Compass deviation card holder; (2) vacuum gage; (3) clock; (4) turbo warning; (5) fuel pressure gages; (6) radio compass indicator (optional); (7) remote compass indicator; (8) turn indicator; (9) flight indicator; (10) manifold pressure gages; (11) coolant temperature gage; (12) fuel quantity gage (front); (13) altimeter; (14) airspeed indicator; (15) bank and turn indicator; (16) rate of climb indicator; (17) tachometers; (18) carburetor air temperature; (19) fuel quantity gage (rear) (20) hydraulic pressure gage; (21) bank and turn regulating valve; (22) landing gear and flap indicator; (23) engine gages; (24) radio contactor; and (25) ammeter.

Air intake scoops on the outboard sides of the forward booms provide air for the induction system. From the scoop air passes through an intake filter, if desired, and through the intake duct to the turbosupercharger compressor. It is discharged from the compressor into a duct leading to the intercooler and thence enters the engine induction system where it is mixed with fuel and distributed to the engine cylinders. AiResearch intercoolers are



Details of fuselage side, with: (1) upper shear web assembly; (2) floor assembly; (3) channel-main beam attachment; and (4) lower outboard shear web assembly.



Hydraulically-operated main landing gear retracts up and back into wells in forward booms. Details shown here include: (1) boom support pivot; (2) drag link; (3) main gear assembly; (4) brake; and (5) wheel.

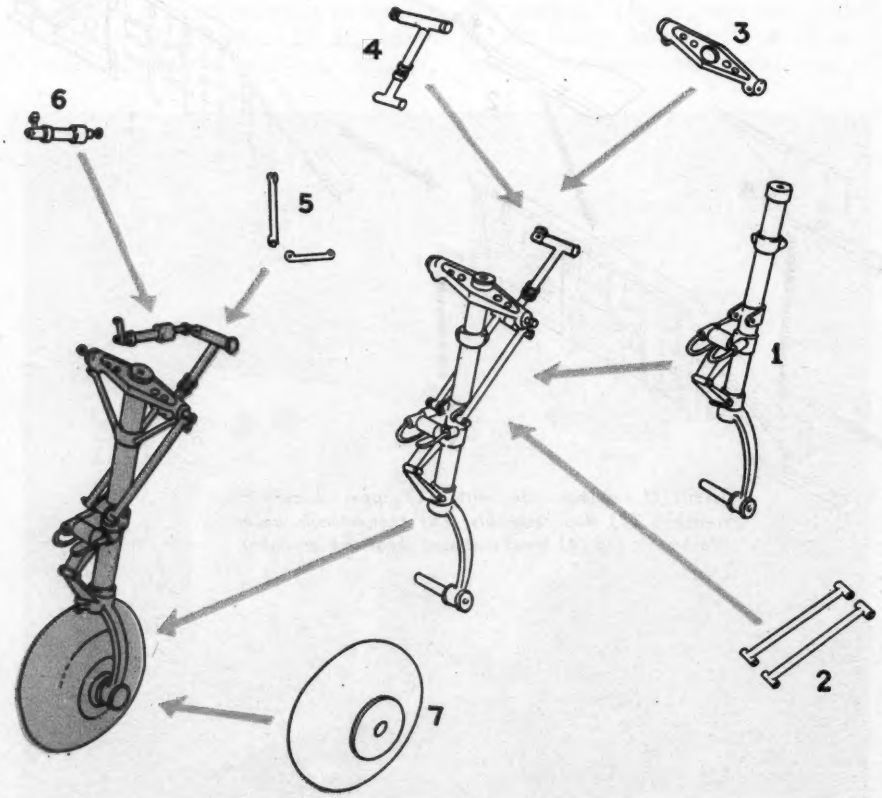
mounted on four Lord mounts bolted to the engine trusses. The cooling air flow through the intercooler radiator may be manually controlled by an electric motor-operated shutter.

Superchargers are General Electric, exhaust-driven turbo type mounted as previously mentioned, immediately behind the rear shear beam of the wing in the forward booms. Automatic electric regulators are connected through a push-pull rod and bellcrank linkage from the throttle control pulley at the firewall and operate in combination with the throttles.

The hydraulic system of the P-38 operates the landing gear, landing gear doors, wing flaps, coolant radiator exit flaps, and aileron boosters. Pressure is supplied by two engine-driven variable volume pumps and maintains a fluid pressure in the system of 1,350 lb. per sq. in. An auxiliary hand pump with a reserve supply of fluid provides for the operation of all units should the drive system fail. An emergency hydraulic system with separate lines and reservoir using the auxiliary hand pump for pressure source, provides a means of extending the landing gears in case the main hydraulic system fails. Fluid capacity of the main system is 10 gal. and aluminum alloy tubing is used throughout the airplane, with all tubes grounded by means of bonding clips and fairleads.

Oil filtering is accomplished at the reservoir in such a way that no unfiltered fluid can reach the system from either return line or by refilling. The hydraulic system is supercharged for maximum high altitude efficiency.

Electrical system is 24-v. dc. single wire except for the 115-v. alternating current supplied by the inverter for the remote compass. A 24-v. battery is



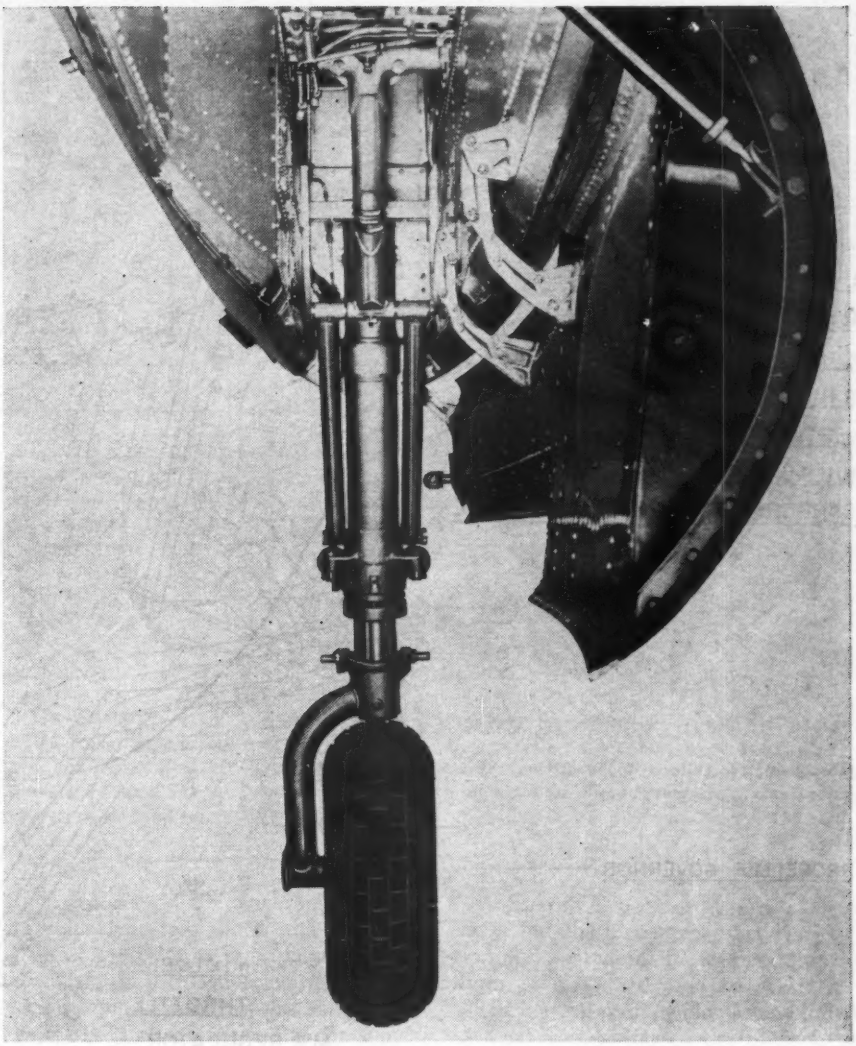
Nose wheel retracts back and up into well in fuselage. This exploded view shows: (1) nose gear assembly; (2) drag struts; (3) fulcrum; (4) torque lever; (5) side struts; (6) actuating cylinder; and (7) 27-in. wheel.

supplemented by two 100-ampere generators to provide power to drive motors and to operate radios, actuating solenoids, instruments, lights and heaters. Engine starters, oil cooler and intercooler flaps, auxiliary fuel pumps, remote compass inverter, turbo regulator, dive flaps, and propeller motors are all electrically powered. Electric solenoids control the armament, droppable tanks and bombs, and outer wing tank flow, oil dilution valves, and coolant flap override mechanism. Electrically operated instruments include the landing gear warning lights; oil, coolant and carburetor air temperature indicators; fuel level gages, remote compass indicator, and tachometers.

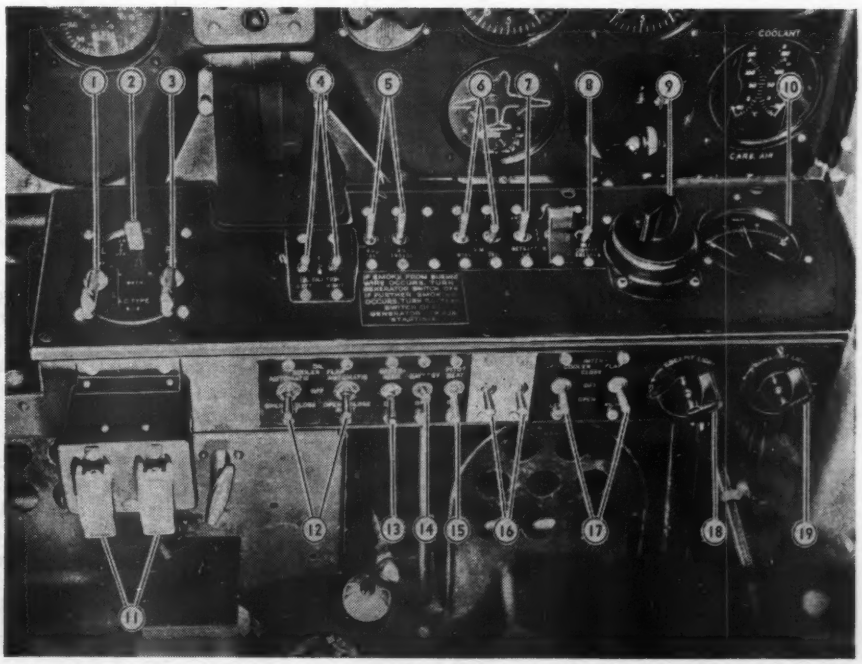
Armanent of the P-38 is unusual in that four 50-cal machine guns and one 20-mm. cannon, firing in a 20-in. diameter, or a 20 x 8 in. rectangular pattern have been proven one of the most effective combinations ever mounted in a fighter. The small number of the guns is more than overcome by their concentration in the fuselage ahead of the pilot, where they fire straight ahead rather than in a converging fire from wing guns.

The gun compartment is located in the upper forward portion of the fuselage. Machine gun ammunition is contained in four drawer-type trays. Cannon ammunition is provided from a drawer type tray. Expended links and cartridge cases are discharged through chutes leading to openings in the skin below the armament compartment. Expended cannon shell cases and links are discharged into a compartment between bulkheads on the lower right hand side of the fuselage. Sighting is by means of a Lynn gun sight, installed on the center line of the airplane, just aft of the bullet-proof windshield.

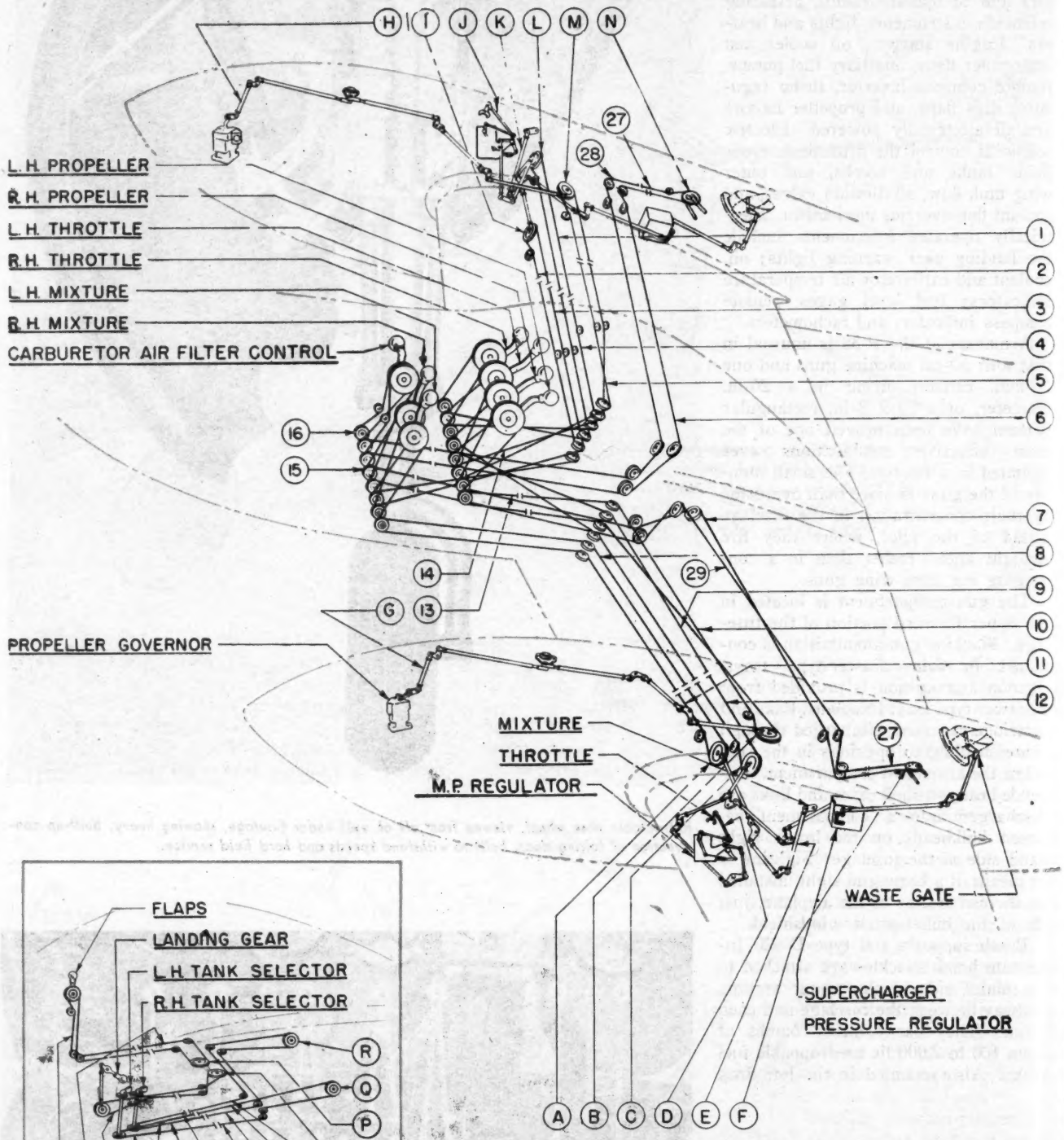
Bomb supports and type D-820 Interstate bomb shackles are attached to the under side of the center section, midway between the fuselage and each boom. They carry either bombs of from 100 to 2,000 lb. or droppable fuel tanks. Also mounted in the left drop

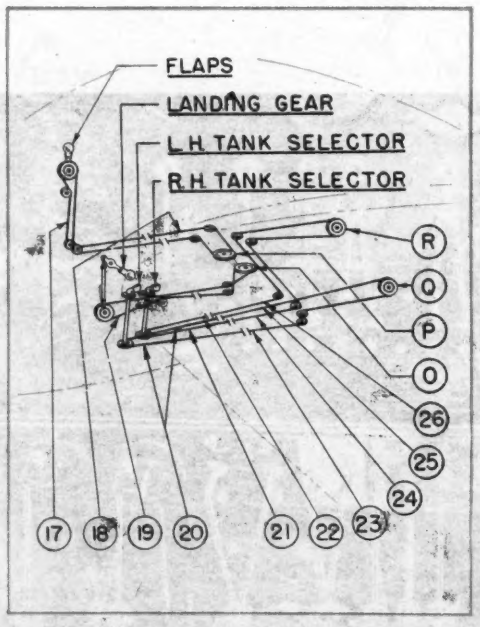


Retractable nose wheel, viewed from aft of well under fuselage, showing heavy, built-up construction of fairing door, built to withstand speeds and hard field service.

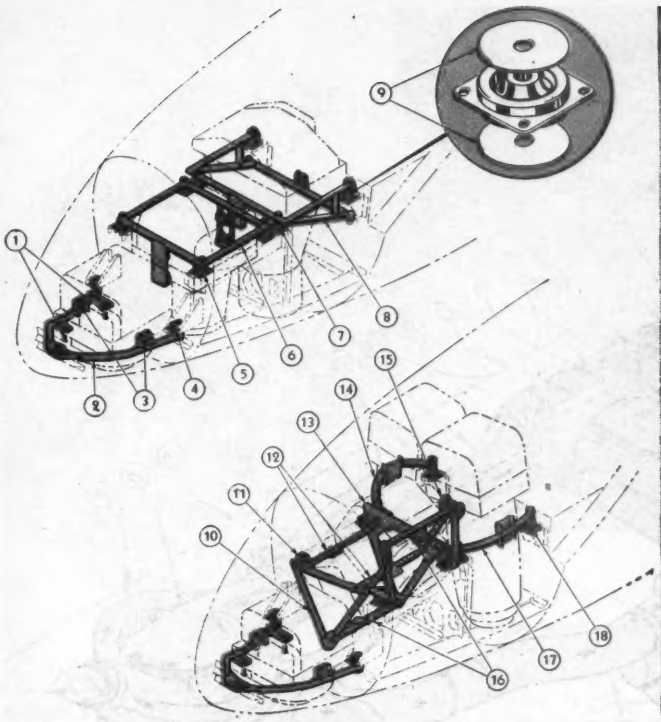


Main switch box, showing: (1) left ignition; (2) master ignition; (3) right ignition; (4) oil dilution; (5) engine starter; (6) position light; (7) left landing light; (8) remote compass switch (circuit breaker); (9) fluorescent cockpit light rheostat; (10) voltmeter; (11) propeller feathering switches; (12) automatic oil cooler flap; (13) generator; (14) battery disconnect; (15) pitot heater; (16) automatic coolant control override switch; (17) intercooler flap; (18) cockpit light; and (19) gunsight light.

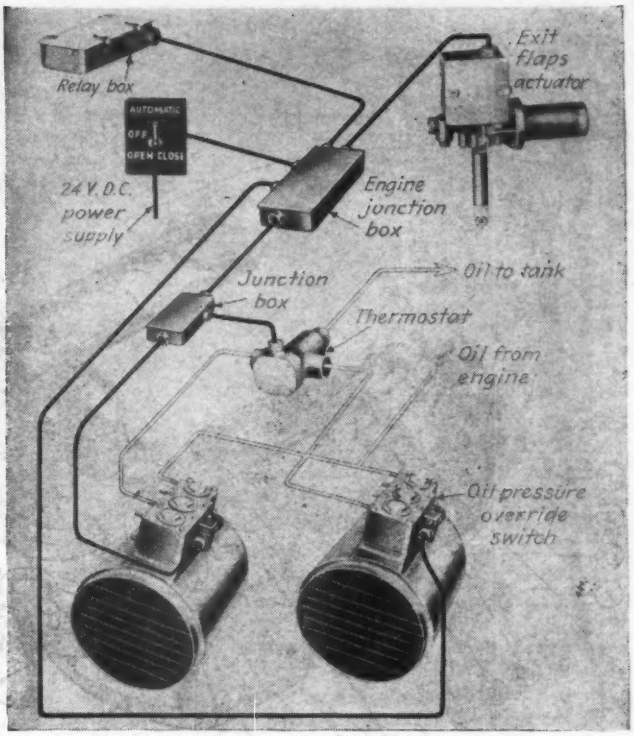




Phantom view of wing flap, landing gear and engine control system showing: (1) right throttle; (2) and (3) right mixture; (4) right throttle; (5) right propeller; (6) right carburetor air, center; (7) left carburetor air, center; (8) left mixture; (9) left throttle; (10) left propeller; (11) left mixture; (12) left throttle; (13) left propeller; (14) right propeller; (15) and (16) left and right carburetor air forward; (17) and (18) fore and aft flap 4-way valves; (19), (20) and (21) left and right tank selectors; (22) right tank selector; (23) left selector; (24) right tank selector; (25) left tank selector; (26) right tank selector; (27) left and right carburetor air, aft; (28) and (29) right and left carburetor air, center; A, B, and C pulley bracket assemblies; D, allison rod—left throttle; E, rod—left mixture; F, pulley bracket assembly; G and H, rods, left and right propeller governors; I, pulley bracket assembly; J, allison rod—right throttle; K, rod right—mixture; L, M, and N, pulley bracket assemblies; O, pulley; P, pulley assembly; Q, and R, drums.



Phantom view of the camera cradle installation on F5-B photographic version showing: (1) camera set screws; (2, 6, 8, 14, and 17) cradles; (4, 5, 7, 11, and 18) Lord mounts; (9) bumper washers; (10 and 13) truss assemblies; (12, 15 and 16) supports and (3) caps on cradles.



Diagrammatic layout of P-38 "Lightning" oil cooling system, showing connections running from oil radiators, through thermostat and junction boxes to flap actuator.

tank support fairing is a type M-6 gun camera. It may be operated independently or in conjunction with the guns.

Armor plate consists of small pieces of face-hardened steel, attached separately to facilitate handling, removal and replacement. The pilot is protected from frontal attack by armor plate mounted on the aft bulkhead of the armament compartment and by a bullet-proof glass windshield. Two pieces of armor plate line the back and bottom of the pilot's seat and give protection from below and behind. A single piece of armor plate mounted behind and above the seat provides additional rearward protection. Armor plate on inboard sides of the superchargers or circular deflectors on the superchargers protect the pilot against possible fragmentation of turbosupercharger blades.

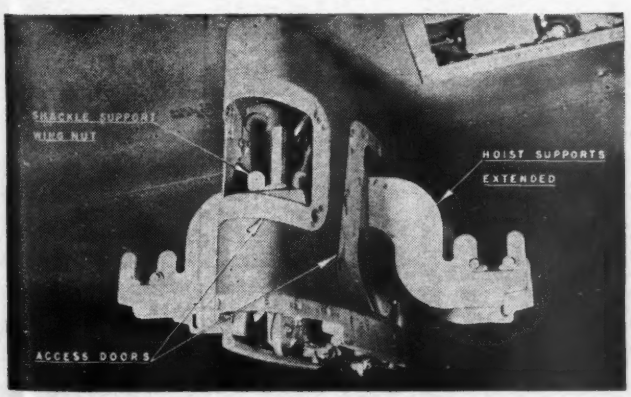
The photographic version, known as F-5B, is a modification of the standard P-38J. The armament compartment is redesigned to accommodate any one of four arrangements of aerial cameras. Combinations of type K-18 with 24-in. lens cone and type K-17 with 6, 12, or 24-in. lens cones are used in each arrangement. Cameras are remotely operated by a type A-1 electrical control and the camera lens apertures are controlled by a remote diaphragm control.

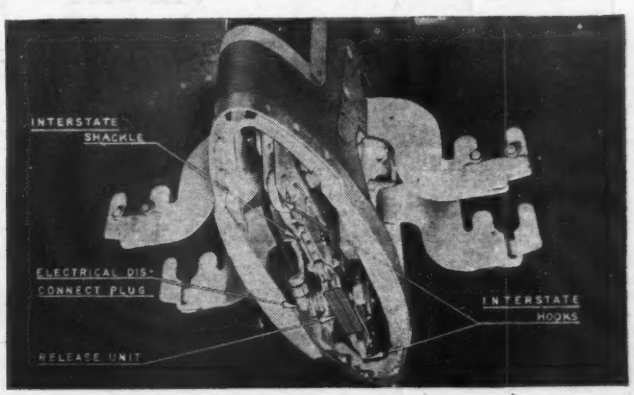
A Sperry Type A-4 gyro pilot provides automatic control of the direction and attitude of the camera ship in flight.

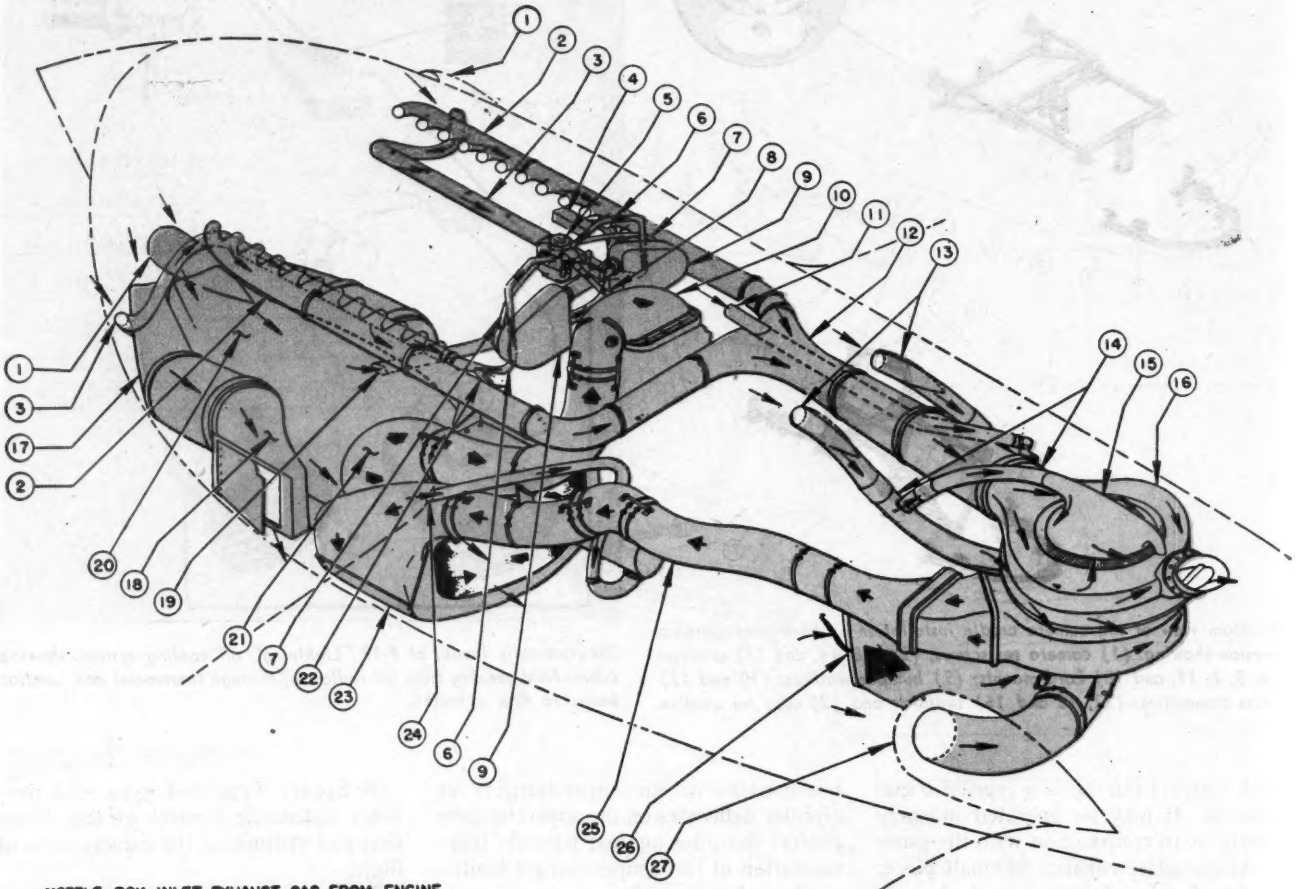
The control units, which are mounted in the lower center of the instrument panel give the pilot a visual check on the operation of the automatic pilot at all times in addition to serving as flight instruments when the automatic pilot is not in use. It uses the airplane's vacuum and hydraulic systems as power sources for its operation.

Furnishings include, in addition to pilot's seat, flare pistol, glare shield, and other standard items, a rearview mirror fastened to the front portion of

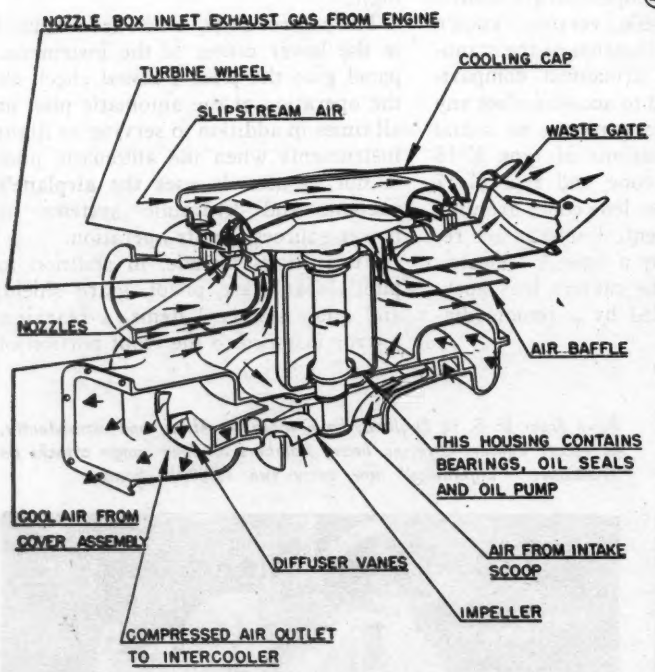
Two views of bomb or auxiliary fuel tank shackles, with front access doors removed. Located on each side of fuselage inboard of engines, these units support tanks which have given P-38's range enough to be flown from U. S. to England; from there to Africa and, consistently, as escort fighters covering heavy bombers on long range attacks on Germany. "Lightnings" now carry two 2,000-lb. bombs.



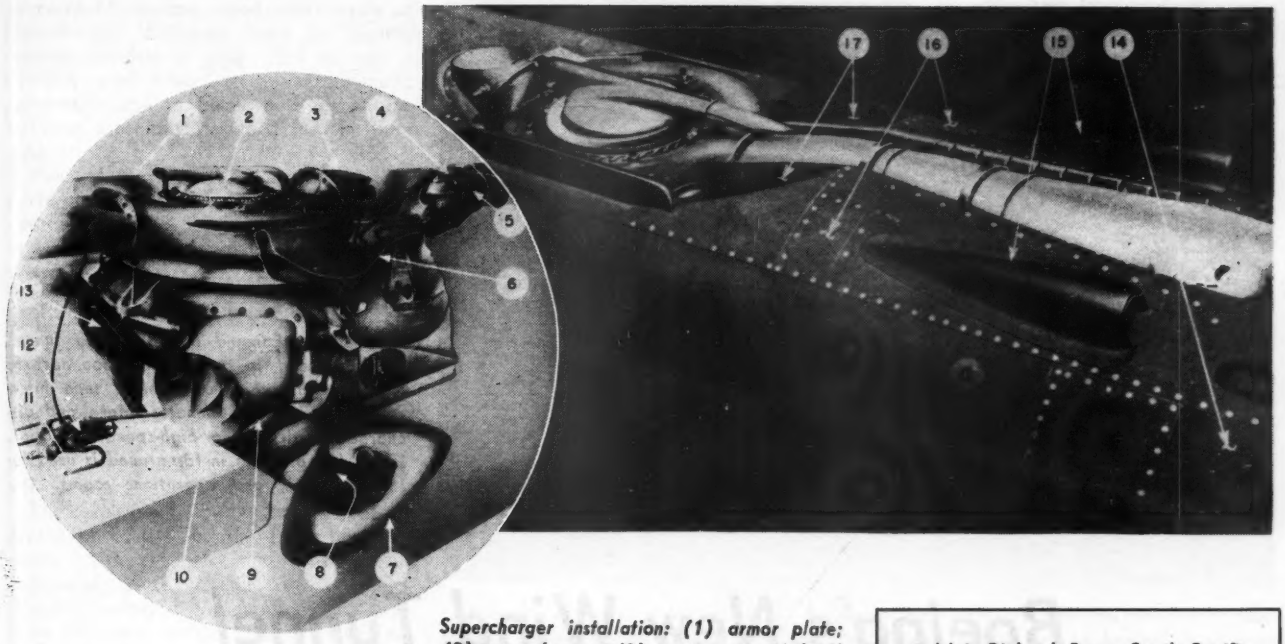




Phantom view giving supercharger installation: (1) Scoop—exhaust manifold and shroud; (2) exhaust manifold; (3) sparkplug blast tube; (4) electrical relay box; (5) magneto; (6) magneto blast tube; (7) air pressure to distributor housing; (8) air pressure to magneto unit; (9) distributor housing; (10) carburetor intake duct; (11) intensifier tube—cabin and armament heat; (12) exhaust "Y" tail pipe; (13) cover assembly—supercharger baffles; (14) blast tube supercharger main bearing and cooling baffles; (15) cooling cap supercharger; (16) B-33 supercharger (for detail of supercharger see insert below); (17) intake scoop—oil cooler regulator; (18) exit duct—oil cooler regulator; (19) duct to electrical oil cooler relay; (20) intake scoop—intercooler; (21) exit duct—intercooler; (22) blast tube to tachometer generator; (23) intercooler unit; (24) generator blast tube; (25) intake duct—intercooler; (26) air filter, and (27) supercharger air intake scoop.



CUTAWAY SHOWING OPERATION OF SUPERCHARGER



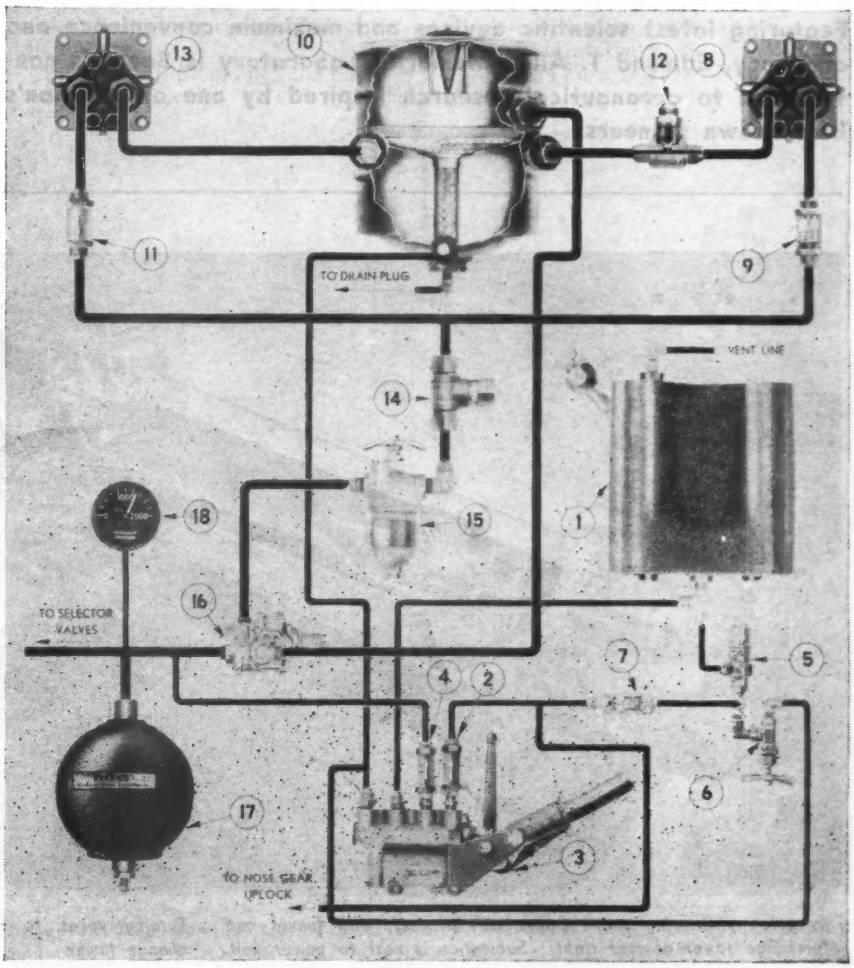
Supercharger installation: (1) armor plate; (2) supercharger; (3) waste gate; (4) oil tank vent line; (5) oil tank; (6) stainless steel structure; (7) supercharger air intake scoop; (8) air intake; (9) duct; (10) air outlet to intercooler; (11) to engine oil system; (12) supercharger regulator; (13) center section rear shear beam; (14) panel assembly; (15) and (16) cover assemblies; and (17) inboard deck assembly.

the top hatch, a demand oxygen system, and a cockpit heating system.

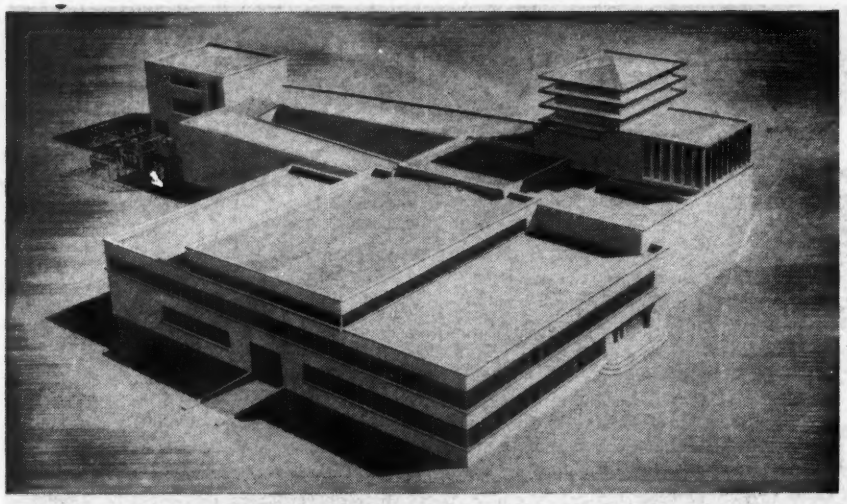
Cockpit heat is by hot air, the intensifier tube in both engine exhaust manifolds being ducted into the cockpit and directed on the pilot's feet. A flexible defroster tube may be used to defrost the top of the canopy.

While much of the design and equipment information given here probably appears as "standard" now, it should be recalled that when the P-38 first introduced it, such was not the case. And every design feature, every installation, every alternate was introduced through necessity to meet the new conditions encountered at the *Lightning's* higher speed and ceilings. With the recent addition of dive flaps and aileron boosters, the *Lightning* again pioneers through use of these devices to help combat the effects of compressibility. The P-38 thus overcomes any disadvantages of large size and weight. The present airplane is an improvement upon the plane the enemy so aptly named the "Fork-Tailed Devil."

• Maj. Richard Bong, South Pacific P-38 ace with 27 victories to his credit, recently inspected and flew the new *Lightnings* with dive flaps and aileron booster. In the new job, he said, he found already in production the answers to all the suggestions he had intended to offer.



Diagrammatic layout of hydraulic system up to accumulator, showing: (1) emergency reservoir; (2) emergency pump check valve; (3) hydraulic hand pump; (4) hand pump check valve; (5) emergency system relief valve; (6) bypass valve; (7) emergency return check valve; (8) right hand engine pump; (9) right hand pump check valve; (10) main system reservoir; (11) left hand pump check valve; (12) suction test check valve; (13) left hand engine pump; (14) pressure test check valve; (15) main system filter; (16) pressure regulator; (17) accumulator; and (18) system pressure gage.



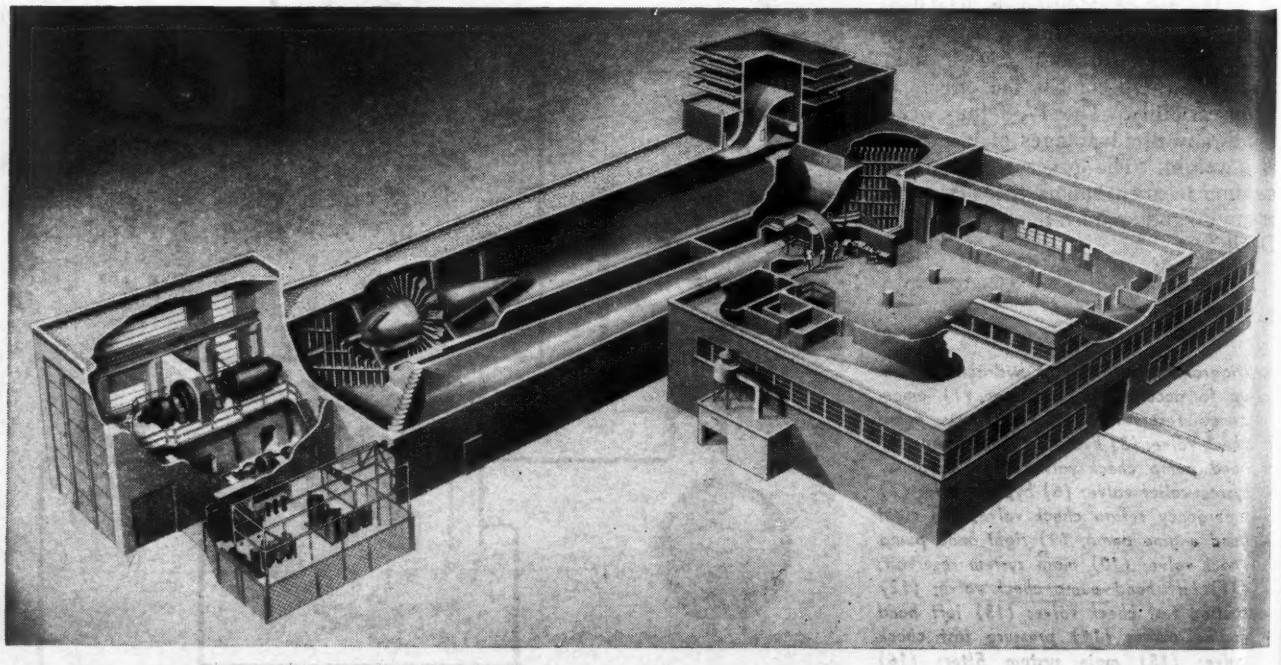
New Boeing Edmond T. Allen wind tunnel. In background is power substation next to engine room, while at right is seen interchange tower which handles intake and discharge of air during high-speed operation. Large, low building in foreground is used for shops, offices, and operations rooms.

Boeing's New Wind Tunnel Accelerates Research

By WELLWOOD E. BEALL,
Vice-President in Charge of Engineering, Boeing Aircraft Co.

Featuring latest scientific devices and maximum convenience and efficiency, Edmund T. Allen Memorial Laboratory is Boeing's contribution to aeronautical research inspired by one of aviation's best known pioneers.

ALTHOUGH it was not deliberately designed to be unique or to incorporate untried and unproven theories, the Boeing Aircraft Co.'s new Edmund T. Allen Memorial Aeronautical Laboratory does contain many features that are innovations. Not only is its wind tunnel the fastest large tunnel in America, but the entire laboratory sets a criterion for convenience. The installation was inspired by the late "Eddie" Allen and the work he did. Faced with the delays



This cutaway drawing shows power unit at left, with tunnel and interchange tower at rear right. Substation is next to power unit. Turning vanes, to reduce eddying at corners, are next to interchange tower.

inherent in running aerodynamic tests at considerable distances from its plants, Boeing decided in Aug. 1941 to add a modern wind tunnel to its aerodynamic laboratory and to house both in a new building especially designed for the purpose.

Two of the world's most famous experts on wind tunnels, Dr. Th. von Karman of California Institute of Technology and Prof. John Markham of Massachusetts Institute of Technology, were called in as consultants, and thousands of hours of preliminary research and experiments were invested. Existing tunnel designs were studied, and all known tunnel features and devices were checked before those considered the best for each purpose were selected, improved upon wherever possible, and combined into one compact, self-contained experimentation unit.

The result is an aerodynamic laboratory devoid of costly building frills but furnished with the best and most useful equipment it is possible to assemble. Roughly L-shaped, the building comprises three separate units. Butted together, these form what appears as a single structure, but there are actually three, each of widely different construction.

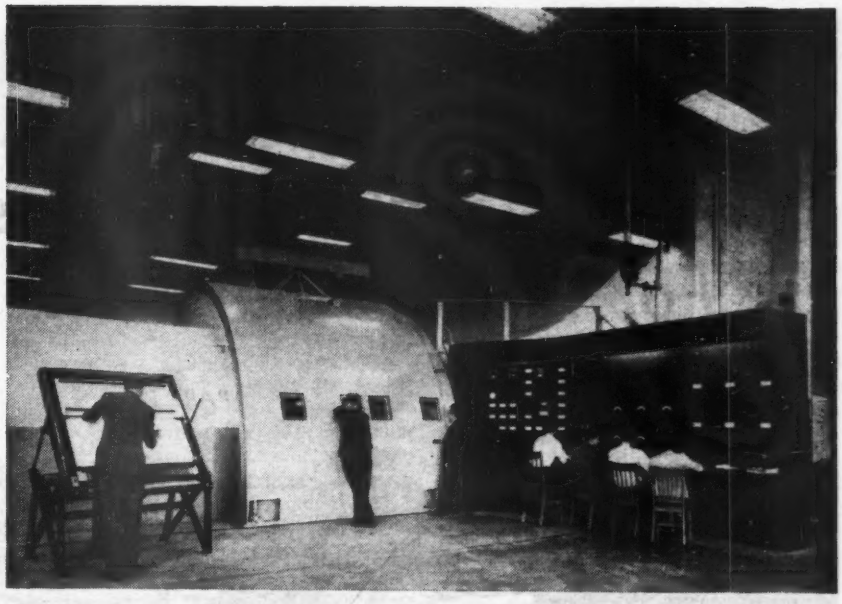
Of more or less conventional design, the laboratory unit is a two-story brick and concrete building, 85 ft. wide x 140 ft. deep, the walls of which contain a high percentage of windows. In it are the offices, operations area, calibration and nacelle testing section, lobby, and model shop, the latter being on the ground floor below the office section. Those portions of the building in which people work are well acoustified.

Adjoining the administration building and extending back beyond it is the wind tunnel section and its adjoining power plant. The tunnel building is 65 ft. wide and 210 ft. deep, with the 35 ft. wide and 50 ft. deep power room extending the over-all length of the tunnel wing to 260 ft.

Construction of the complete unit, which was under the direction of The Austin Co., required more than 210,000 sq.ft. of plywood and other lumber for the forms, into which were poured 7,500 tons of concrete. Inner concete surfaces of the tunnel were poured to a tolerance of $\frac{1}{16}$ in. and after hardening, were ground smooth, polished, and painted. Result is a tunnel that is comparatively noiseless and vibration-free, both characteristics unusual in wind tunnels.

The laboratory building, tunnel, and equipment represent an investment of approximately $750,000, and the design is such that, when needed, another tunnel of different design and for entirely different uses, can be added.

While every effort was made to make the tunnel both modern and convenient, there also was a decided aim to keep it conservative. After preliminary designs were completed, a model of the tunnel was built in wood on a 1/20th scale and tests were conducted for months to check every detail of performance and convenience of operation. These tests revealed that many changes should be made. The resulting design, built entirely of concrete,



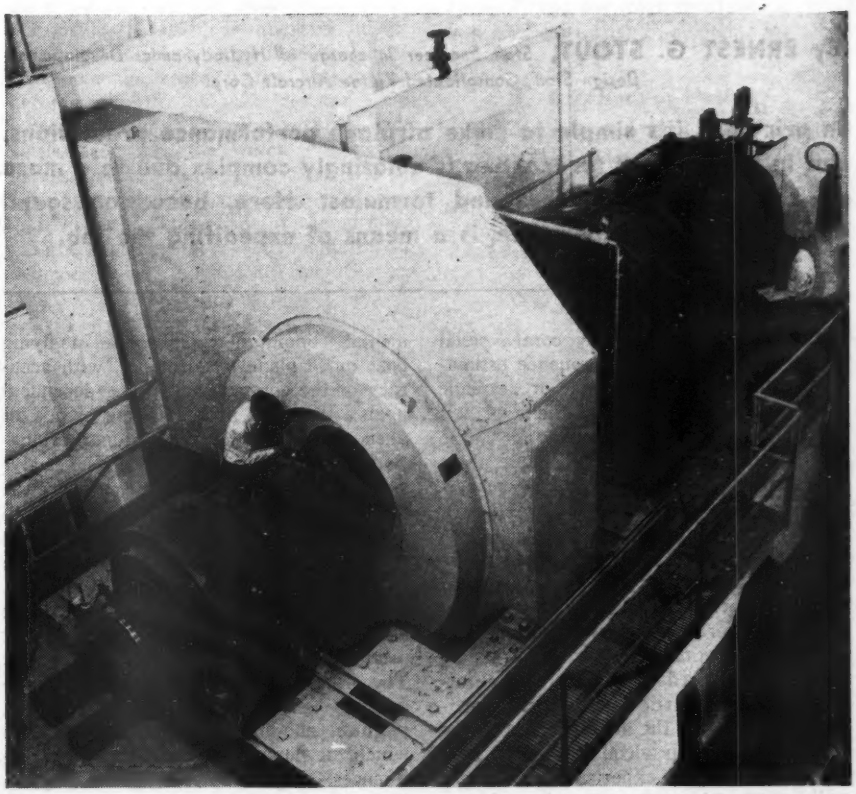
Test section of tunnel slides on tracks. Bellmouth is at right and 100-tube manometer easel at left. Entire interior is lined with soundproof tiling. Models can be brought in by overhead track from workshop. Controls and instrument panel are at right.

produces speeds in the 700 mph. range, or closely approaching the speed of sound.

The Boeing tunnel differs from most in that it is 27½ ft. sq. at its greatest cross-section dimension, with reduction to 8 ft. x 12 ft. at its throat. The wind course, 450 ft. in length, is formed by two reverse-tapering, parallel sections connected at both ends. It is designed to provide maximum usefulness for an estimated 10 yr. period.

Circulation of air through the tunnel is by means of a 24-ft., 16-blade spruce fan designed and built by Boeing engineers and craftsmen. Pre-rotation vanes on the upstream side of the fan give the air a twisting impulse before it strikes the fan itself. The fan, in turn, twists the air in the opposite direction so it leaves the blades with a minimum of twist or swirl. The hub of the fan has a large, nacelle-like fairing designed to eliminate air turbulence.

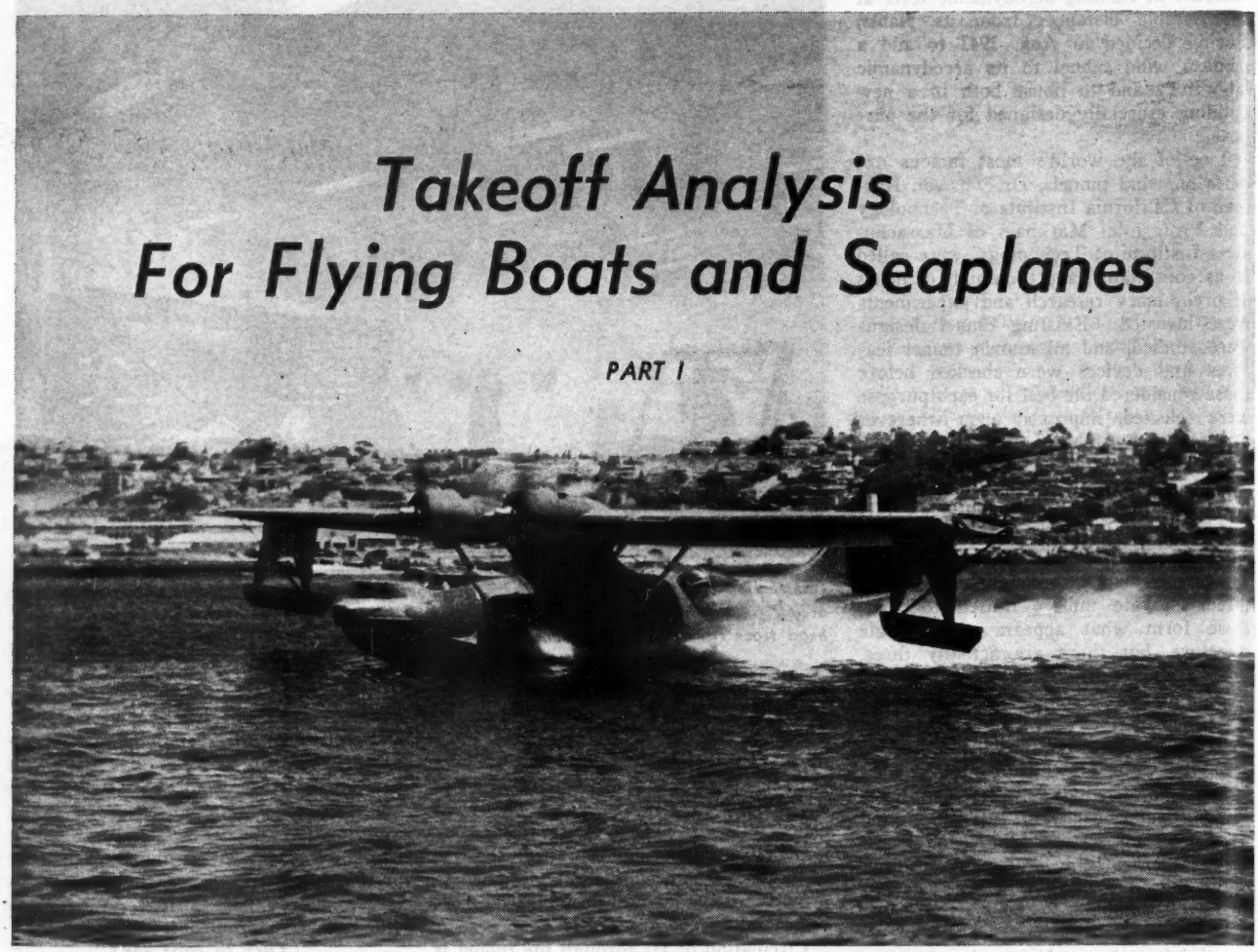
(*Turn to page* 248)



Huge 18,000-hp. motor in cooling hood, with electric clutch (right) and 400-hp. starting motor (left) used to run main motor up to speed before applying power.

Takeoff Analysis For Flying Boats and Seaplanes

PART I



By ERNEST G. STOUT, *Staff Engineer in charge of Hydrodynamics Development, Design Staff, Consolidated Vultee Aircraft Corp.*

In *principle*, it's simple to make airplane performance predictions. But in *reality* such forecasting is amazingly complex due to a maze of conflicting procedures and formulas. Here, based on sound theory and long experience, is a means of expediting the job.

ONE OF THE MOST controversial phases in the performance estimation of a flying boat or seaplane is the accurate prediction of the airplane's performance during the takeoff. While the physical principles are simple their evaluation is complex, and no serious attempt has been made to introduce a standardized procedure.

Most engineers, called upon to make such an analysis for the first time, are confronted with a confusion of empirical charts and formulas, rules of thumb, and a slight infiltration of theory. This article has been prepared in an effort to eliminate the major portion of conflicting procedure and to put the analysis on a sound footing based upon adequate theory coupled with extensive experience in the experimental and service operation of seaplanes.

Analysis of takeoff is one of the fundamental computations involved in flying boat or seaplane performance, with accuracy of the computations being dependent upon a thorough understanding of takeoff phenomenon coupled with proper evaluation of equations of motion. The analysis is complicated to some extent by the fact that the load supported by the hull is continually changing with speed, due to the varying proportion of load being supported aerodynamically by the wing. Getaway speed is that speed where the load is totally supported by aerodynamic means and the airplane becomes airborne. The takeoff run from zero velocity to getaway may be divided into four speed regimes, one blending into the next, in which the flow patterns show marked differences. Fig. 1 shows a takeoff diagram illustrating the normal curves of the forces and trims.

First stage is the displacement period, where there is no difference hydrodynamically between planing and displacement hulls. The change in trim is very small due to the resultant of the total water forces, the plane having moved but slightly from its position at rest. Even though the relative speed between the water and the step, during the final portion of the range, is sufficient to cause separation of flow at the step, the trough or wake formed behind the step is short, resulting in the major portion of the afterbody still functioning as a displacement body.

The planing-type hull is usually of inherently poor design for this type of operation, and the resistance is relatively high. Due to the great amount of acceleration or excess thrust at this point, the effect on total takeoff time or distance is small. Primary function of the afterbody during this stage, as at rest, is to provide a bow-down reaction which, if not present, would result in excessive high trim accompanied by prohibitive resistance.

Because of the low trim and high hull loading during this stage the spray is at a maximum, and with heavy wetting of the engines and propellers there may be great prolongation of the takeoff. In some cases, the takeoff may be impossible. Because of the adverse spray characteristics, this regime is commonly called the "ploughing stage." Every

effort is made by the pilot to increase the trim as rapidly as possible by smooth application of the power and the use of up elevator.

In the second stage, as the relative speed between the water and the step increases, the trough behind the step increases and the contact between the water and the afterbody bottom moves progressively aft. Because of the action of the step during this stage, the hull deviates from the displacement curve of resistance and enters a period of transition to pure planing. The process of getting on the step is usually characterized by a rapid emersion of the hull occurring within a narrow speed range.

During this period the resultant of the water forces reaches its most forward position, causing a marked increase in trim. As the extreme after portion of the afterbody remains in contact with the water, a bow-down moment is produced which limits the rise in trim to reasonable values. Rise in trim is accompanied by a rise in resistance, both peaking at very nearly the same speed—the point at which the transition becomes complete and planing begins. Speed at which the trim and resistance curves peak is referred to as the "hump" and, because of the proximity of the two, the term is commonly referred to either function without qualification. By its nature, this regime is commonly referred to as the "transition stage."

Due to the appreciable unloading of the hull aerodynamically and the decrease in immersion and increase in trim from the hydrodynamic forces, the spray passes below and aft of the propellers and ceases to be critical. The pilot usually assists the establishment of planing through the application of down elevator in the hump range. In certain cases, usually at very high loads or when taking off from slick water, the pilot can assist in establishing planing by rocking the hull through alternate application of up and down elevator. Because of the critical nature of the hump phenomenon it is extremely important that great care be exercised during the analysis of this stage.

The third stage is a period of pure planing on the forebody alone in which the afterbody contributes nothing to the performance and, if poorly designed, may be a detriment due to interference effects. A complete treatment of the planing function will be treated in a subsequent article.

The trough formed by the forebody now passes beyond the afterbody, and the entire hydrodynamic reaction is confined to the planing bottom ahead of the step. As the dynamic pressure increases and the wing increases rapidly in effectiveness, the pressure area becomes shorter. The resultant water force shifts aft, and the trim of the hull decreases. As the speed continues to increase, the free trim tends to become less than the best trim for minimum resistance, requiring the pilot to exert a slight steady pull back on the elevator control. Spray is of no consequence during this period, and the water resistance continues to decrease throughout the range because of rapid decrease in load and draft.

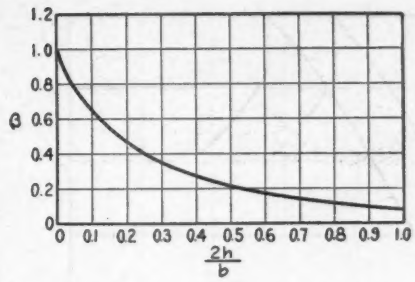


Fig. 2. Plotting aerodynamic ground effect.

In the fourth stage, during the period just before getaway, the draft decreases to such a point that the natural planing beam is less than the geometric beam, allowing a heavy spray from the planing bottom to escape backward and strike the afterbody.

This is aggravated by the increase in trim necessary to pull the wing up to takeoff attitude. The tangential contact of this water with the afterbody increases the frictional resistance so much that under some conditions where the getaway speed is high, due to high wing loading, this resistance plus the increment due to aerodynamic effects may, despite the small load left on the water, equal the thrust available—and takeoff becomes impossible.

The fourth stage is primarily a period of transition, in this case from water planing to airborne. If best planing trim were maintained, the wing would remain at such a low angle of attack that the getaway speed would be excessively high. At some point, prior to actual getaway, the pilot must gradually pull up elevator and increase the trim to obtain the minimum takeoff time and distance.

Considerable skill is involved in this maneuver, for if the trim is increased too soon and the speed is not sufficient to become airborne, the water resistance will increase rapidly and the airplane will settle back into the water. It is then necessary to pick up acceleration and repeat the maneuver, consuming both time and distance. Obviously, if the airplane is lightly loaded and there is ample thrust, it may be held down until ample speed is certain. It then can be flown off with a small increase in trim.

Acceleration Forces

The fundamental forces involved during the takeoff run are thrust and resistance, the latter being further broken down into water or hydrodynamic resistance and aerodynamic drag. Difference between the thrust and the total resistance, if positive, is the net accelerating force T_a, or that force which continues to accelerate the airplane to getaway. If at any point during the takeoff T_a becomes negative, the takeoff time and distance becomes infinite and the airplane will not go beyond the speed at which the sign changes.

Fig. 1, which illustrates the condition for zero headwind, shows that the air drag, curve D, is zero at zero velocity and increases steadily to getaway. If there was no change in trim, air drag would be a smooth curve varying directly with the velocity squared. The local deviations from the smooth velocity squared variation are caused by changes from the average trim which alter the aerodynamic drag coefficient. The water resistance, curve R, is also zero at zero velocity and varies with speed, as described earlier, falling to zero again as the hull leaves the water. These two curves are added to give the curve of $R + D$, which is the total resistance of the airplane.

The thrust, curve T, computed as outlined later, represents the total thrust in pounds of the engine-propeller combination plus any auxiliary thrust that might be used in some cases for assisted takeoff. The variable difference between the thrust curve T and the total resistance $R + D$ is the excess thrust T_a available for acceleration.

Equations of Motion

Newton's second law states that the rate of change of momentum is proportional to the force applied to the body, and it takes place in the direction of the straight line in which the force acts. The derivation of the takeoff equations, both

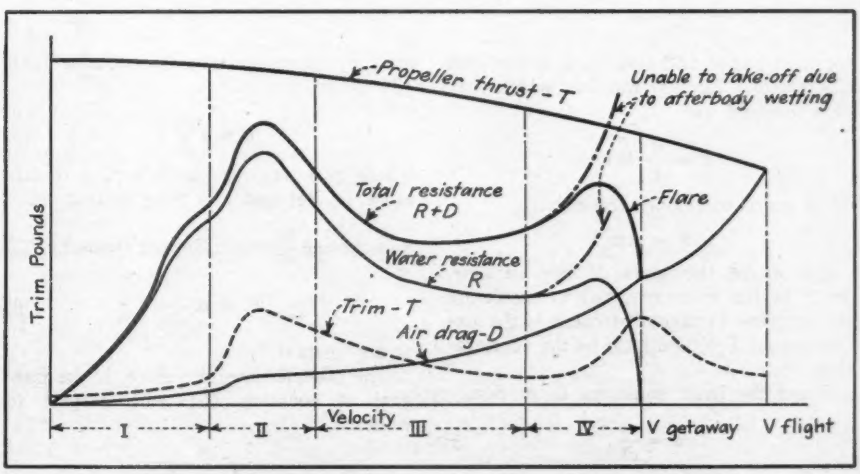


Fig. 1. Illustrating zero headwind conditions, plotting air drag; trim; water resistance; combined air and water resistance; and propeller thrust.

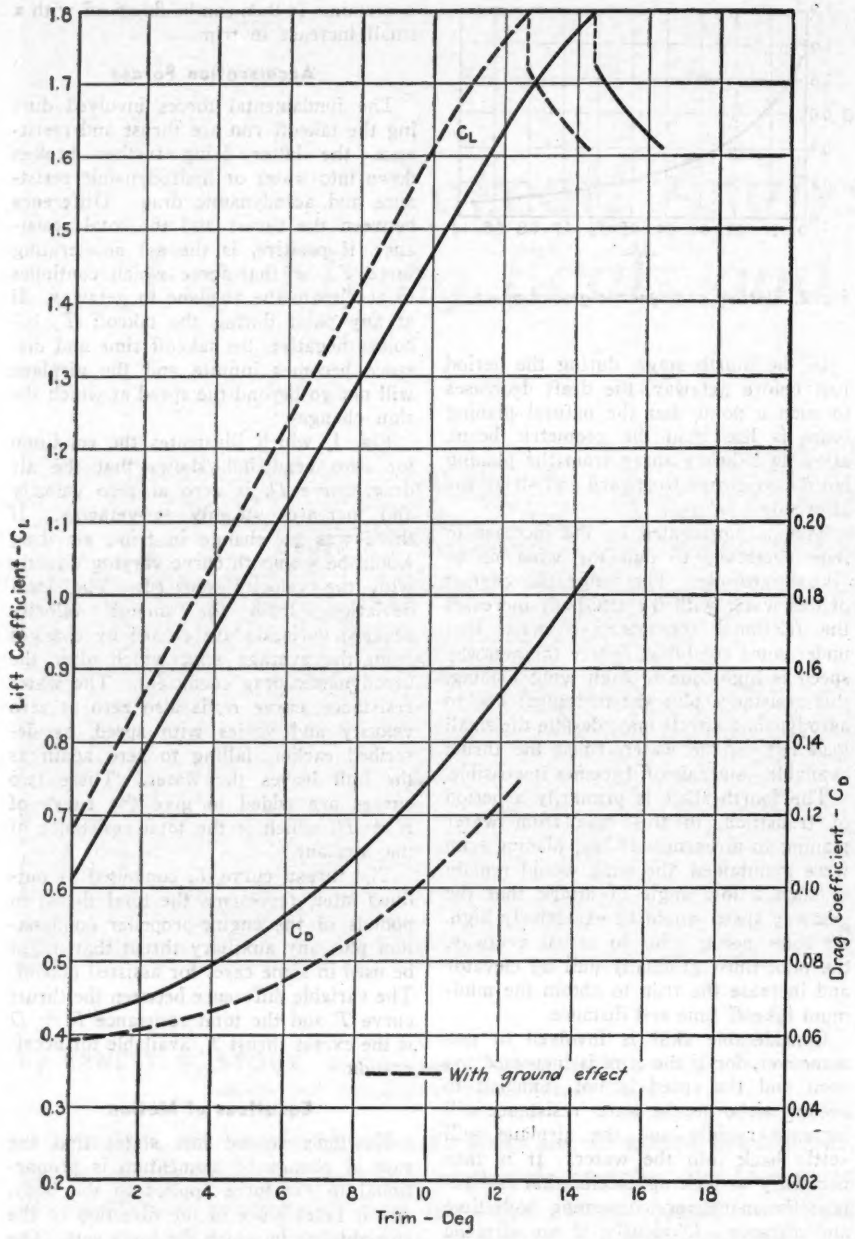


Fig. 3. Showing aerodynamic characteristics (determined by wind tunnel tests and representing free flight) in solid lines, together with determination of lift curve and new drag, as shown by broken lines.

for land planes and seaplanes, starts with the equation form of this law which may be expressed as:

$$F = \frac{d}{dt}(m\,v) \tag{1}$$

or as more commonly recognized,

$$F = m\,a \tag{2}$$

Let m be the mass of the airplane, let F be the force required to accelerate the airplane to takeoff (which is the excess thrust T_e), and let a be the acceleration,

From the basic equations of motion,

$$a = \frac{dv}{dt} \tag{3}$$

$$v = \frac{ds}{dt} \tag{4}$$

multiplying numerator and denominator in (3) by ds,

$$a = v\frac{dv}{ds} \tag{5}$$

where v is velocity in ft./sec., s is distance in feet and t is time in seconds.

Substituting $\frac{dv}{dt}$ for a in Newton's equation (2)

$$T_e = m\frac{dv}{dt} \tag{6}$$

at any instant.

The takeoff time, therefore, is the integral of equation (6) with respect to velocity,

$$t = \int_{V_e}^{V_a} m\frac{dv}{T_e} \tag{7}$$

$$= \int_{V_e}^{V_a} \frac{w}{g}\frac{dv}{T_e} \tag{8}$$

Substituting $v\frac{dv}{ds}$ for a, the expression for takeoff distance, s, is obtained.

$$T_e = mv\frac{dv}{ds} \tag{9}$$

and integrating,

$$s = \int_{V_e}^{V_a} m\frac{v\,dv}{T_e} \tag{10}$$

$$= \int_{V_e}^{V_a} \frac{w}{g}\frac{v\,dv}{T_e} \tag{11}$$

where the limits V_e and V_a are the velocity at rest and at getaway, respectively.

Evaluation of the integrals for takeoff time and distance is by necessity a graphical, step-by-step process because the variation of the accelerating force T_e as we have seen is not a simple one.

Hydrodynamic Nondimensional Coefficients

As in aerodynamics, to facilitate the use of model data to determine full scale forces and to form a basis for dimensional comparison, a system of nondimensional coefficients has been established in accordance with Froude's Law of Comparison which states that if the expression v^2/gl is held constant, gravity forces will vary directly with ratio of the linear dimensions cubed. Due to its primary influence on all hydrodynamic characteristics, the beam is used as the basic dimension of comparison. In the following summary of the basic coefficients, that for speed, C_V, is recognized as the Froude Number:

Load coefficient $C_\Delta = \frac{\Delta}{wb^3}$ (12)

Resistance coefficient $C_R = \frac{R}{wb^3}$ (13)

Trimming moment coefficient $C_M = \frac{M}{wb^4}$ (14)

Speed coefficient $C_V = \frac{v}{\sqrt{gb}}$ (15)

Where: Δ = Load on the water, lb.
R = Water resistance, lb.
M = Trimming moment, lb.-ft.
v = Velocity, ft./sec.
w = Density of water, lb./cu.ft.
b = Beam of the hull, ft.
g = Acceleration due to gravity ft./sec.^{2}

Aerodynamic Ground Effect

During takeoff and landing when the airplane is near the ground or water, the aerodynamic characteristics are different from those in free flight. Here the phenomenon, known as ground effect, is caused by a reflection of the downwash from the ground. It is manifest in an increase in effective aspect ratio of the wing which, in effect, increases the slope of the lift curve and reduces the induced drag of the wing. The method for computing this effect is briefly outlined as follows:

Reduction of the induced angle of attack of a wing system upon approaching the ground is:

$$\Delta\alpha_i = \beta \frac{C_L S}{\pi b^2} \qquad (16)$$

where $\Delta\alpha_i$ is change of induced angle of attack in radians, b is the wing span in feet, and β is the influence factor. In Fig. 2, β is plotted against $2h/b$, where h is the height of the wing above the ground.[1]

In the equation

$$\frac{S}{b^2} = \frac{1}{R} \qquad (17)$$

where R is the wing aspect ratio defined as the span[2] divided by the wing area and the total induced angle of attack is:

$$\alpha_i = \frac{C_L}{\pi R} \qquad (18)$$

Equivalent aspect ratio near the ground is:

$$R_e = \frac{R}{1 - \beta} \qquad (19)$$

Determination of the life curve is therefore:

$$\alpha_2 = \alpha_1 + \frac{C_L}{\pi}\left(\frac{1}{R_e} - \frac{1}{R}\right) 57.3 \qquad (20)$$

and the new drag is:

$$C_{D2} = C_{D1} + \frac{C_L^2}{\pi}\left(\frac{1}{R_e} - \frac{1}{R}\right) \qquad (21)$$

where a and C_D are the geometric angle of attack of the wing and total drag coefficient of the airplane, respectively.

For example: Given the mean height of the wing above the water as $h = 11.0$ ft., basic aspect ratio of the wing $R = 9.0$, and the span $b = 120$ ft., then:

$$\frac{2h}{b} = .183$$

and from Fig. 2, $\beta = .50$

$$R_e = \frac{R}{1 - \beta} = 18$$

and

$$\alpha_2 = \alpha_1 + 18.24\, C_L\left(\frac{1}{18} - \frac{1}{9}\right)$$

$$= \alpha_1 + 18.24\, C_L\,(-.056)$$

$$= \alpha_1 - 1.02\, C_L$$

also

$$C_{D2} = C_{D1} + \frac{C_L^2}{\pi}\left(\frac{1}{18} - \frac{1}{9}\right)$$

$$= C_{D1} - .0178\, C_L^2$$

If we have given the aerodynamic characteristics shown by the solid lines in Fig. 3, which have been determined from wind tunnel tests and represent free flight, we apply equations (20) and (21) for determination of the lift curve and the new drag to determine the lift and drag coefficients when in the proximity of the ground or water, as the case may be. The new curves, with ground effect, are indicated in Fig. 3 by dashed lines.

Table I, using the data given in the example, presents a convenient form for this computation.

Evaluation of takeoff integral: As stated previously the evaluation of the takeoff integrals,

1. Ridley, K. F., "An Investigation of Airplane Landing Speeds", NACA Technical Note No. 349, 1930

Table I—Example of Calculation for Ground Effect

Flaps 20°

1 C_L	2 a_1	3 Δa	4 a_2	5 C_D	6 ΔC_D	7 C_{D2}
.6	−.15	−.61	−.76	.065	−.006	.059
.8	2.20	−.82	1.38	.071	−.011	.060
1.0	4.55	−1.02	3.53	.083	−.018	.065
1.2	6.90	−1.22	5.68	.100	−.026	.074
1.4	9.20	−1.43	7.77	.122	−.035	.087
1.6	11.50	−1.63	9.87	.148	−.046	.102
1.8	14.30	−1.84	12.46	.187	−.058	.129

Column

1. Lift coeff. from wind tunnel data
2. Angle of attack from wind tunnel data
3. −1.02 × col. 1 (ref. example)
4. Col. 2 + Col. 3
5. Drag coeff. from wind tunnel data
6. −.0178 × (col. 1)²
7. Col. 5 + Col. 6

$$t = \int_{V_o}^{V_g} \frac{w}{g}\frac{dv}{T_e}$$

and

$$s = \int_{V_o}^{V_g} \frac{w}{g}\frac{v\,dv}{T_e}$$

is by necessity a step-by-step process. Throughout the evaluation there are many points where judgment and experience is required to prevent errors of considerable magnitude. Upon investigation the engineer will find many techniques and variations in use, in fact rarely will we find any serious attempt toward standardization. As many empirical forms and shortcuts are contingent upon a considerable background of experience, the novice should proceed with due caution in their use.

To eliminate confusion existing in regard to correct technique, the following step-by-step outline has been prepared. The controversial portions of the evaluation have been standardized, with simplified rules of procedure set up. This form has been in use for many years by some of the largest manufacturers of flying boats, and experience has shown that takeoff performance may be consistently predicted (within 2 percent) from towing basin data, providing reasonable care is exercised.

1. Set up a tabular form similar to Table II and fill in the basic airplane data appearing at the top and the constants listed at the bottom. It should be noted that for convenience the velocity in ft. per sec. in the expression for C_V is divided by 1.467, which converts the velocity to mph. This factor is included in the constant. Also, in the expressions for aerodynamic lift and drag L and D, the velocity is in mph.

2. Starting from the left column, the tabular data are filled in step-by-step. Since we are integrating with respect to velocity we pick even increments of speed as the basic parameter. As the data are given nondimensionally the speed coefficient, C_V, is used. Thus beginning with a C_V of 1.0, increments of 0.2 are tabulated in the first column up to a C_V of 3.0. In the high speed range, starting with C_V of 3.0 the increment is made 0.5 to getaway. To determine the end point compute the value of C_V for V_g, (getaway speed).

Because of the transition flare (as described earlier) during the fourth stage of takeoff, the integration is actually stopped at a value of C_V approximately 1.5 less than the C_V for getaway and the $1/a$ curve is faired from that point to getaway. Experience has shown that a well-executed flare starts at a point approximately 1.5 C_V before actual getaway is attained at takeoff trim.

In all formal performance estimation the lift coefficient to be used to determine the getaway speed, V_g, is usually defined as 90 percent of the maximum lift coefficient, C_{Lmax}. This assumption, which has been standardized primarily to put all aircraft on a universal scale of comparison, is usually attainable in practice by only the most skillful pilots for the demonstration of maximum performance. In actual practice a flying boat is rarely stalled off the water in such a manner; on the contrary, extensive experience indicates that

(*Turn to page* 251)

Table II—Take-off Computations

Standard Form

Engine : .....
BHP./RPM. : .....
Gear ratio : .....
Prop. dia. : .....
Prop. A. F. : .....

$C\Delta_0 = \frac{G.W.}{wb^2} =$ .....

Gross weight, lb. : .....
Wing area, sq.ft. : .....
Beam, ft. : .....
Flaps, deg. : .....
C_L @ V_g (0.9 C_L max.): .....

C_V	V mph.	V^2 mph.	T deg.	C_L*	L lb.	Δ lb.	$C\Delta$	CR	R lb.	C_D*	D lb.	$R \div D$ lb.	T lb.	T_e lb.	$1/a$	$Vfps/a$

* Use full ground effect.

$C_V = V fps/\sqrt{gb}$ $\quad Vmph = C_V \times$ ..... $\quad L = .00256 C_L S V^2 = C_L V^2 \times$ .....

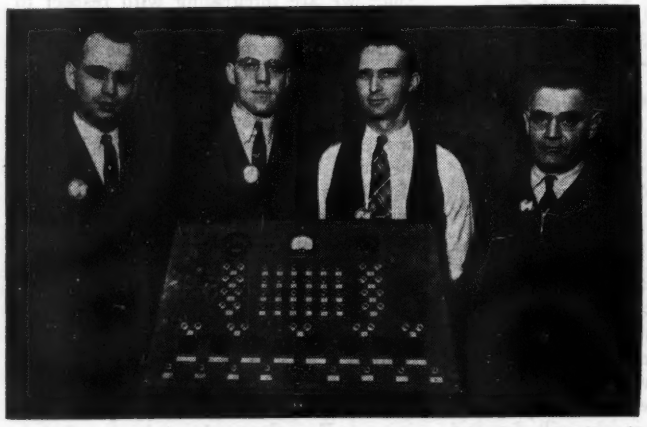
$C\Delta = \Delta/wb^2$ $\quad C\Delta = \Delta/$ ..... $\quad D = .00256 C_D S V^2 = C_D V^2 \times$ .....

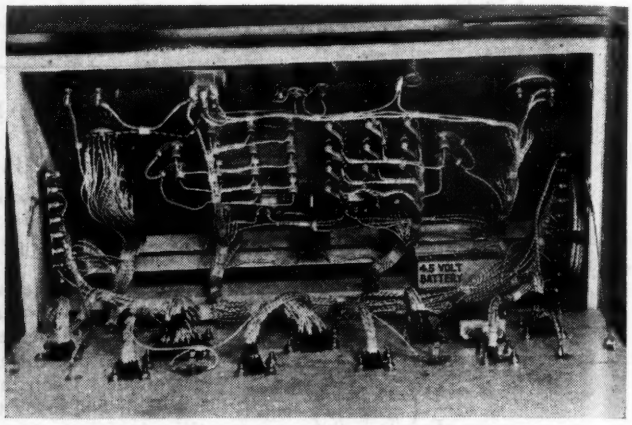
$C_R = R/wb^2$ $\quad R = C_R \times$ ..... $\quad 1/a = G.W./gTe =$ ...../Te

PLANT-PRACTICE HIGHLIGHTS

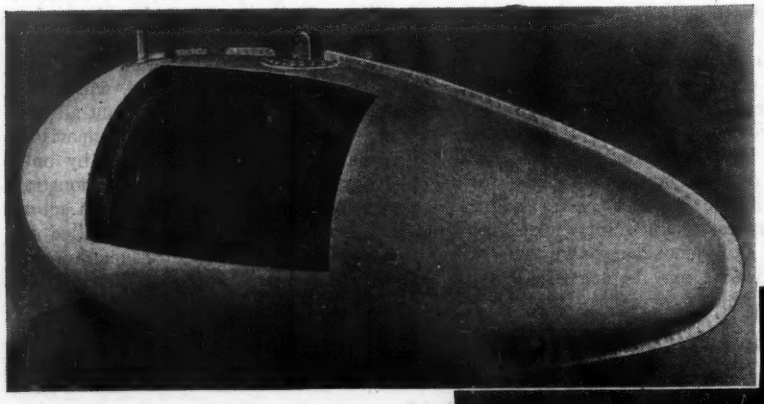
Circuit Analyzer Saves Many Man-Hours

• At Glenn L. Martin, four engineers perfected instrument (illustrated) which enables all B-26 "Marauder" electrical circuits to be tested merely by plugging in connections, thus enabling inexperienced operators to do work formerly requiring trained personnel. Other types of this instrument are being built for testing circuits on PBM-3 "Mariner" and other Martin craft.



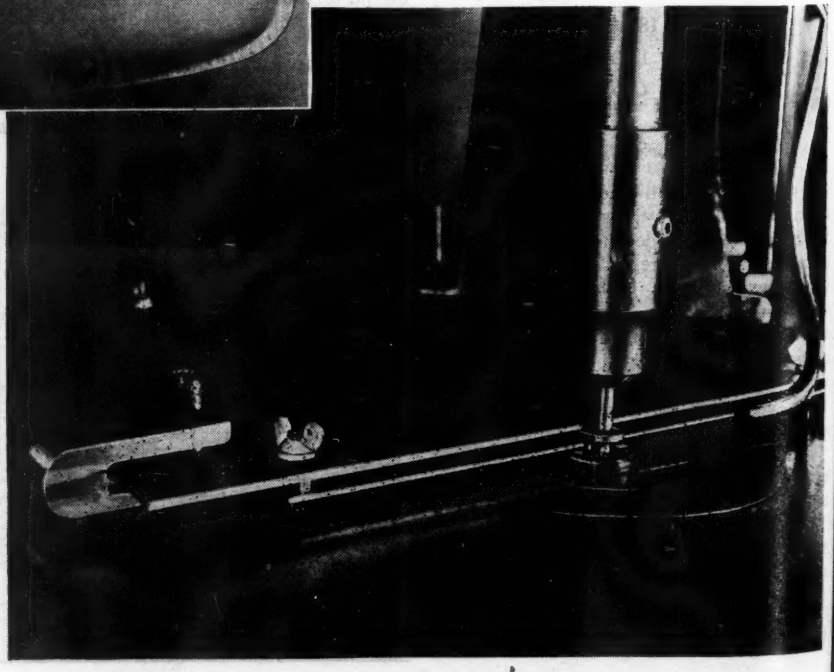


Above: Inventors of circuit analyzer and their instrument. Left to right: J. D. McCallister, H. R. Morawe, W. A. Matson, and J. M. Aldrich, Jr. Right: Rear view of circuits of B-26 "Marauder" analyzer.



Router Attachment Eliminates Hand Filing

• Amos F. Lewis, tool inspector at Curtiss-Wright, invented this template finishing device. It is reported to enable production of finished work at 48 sec. per foot of cut, saving much time. Device consists of a pin, equal in diameter to cutter, which follows edge of master template and guides work against edge of cutter.



Tanks From Fiber and Resin

• Method of combining sisal fiber and Durez resin is used by Columbian Rope Co., Auburn, N. Y. to produce jettison tanks for planes. New tank, pictured here with portion of side cut away to show internal structure, is stated to be advantageous because of its resistance to flying stones and pebbles encountered in takeoffs and landings. In addition, no critical materials are lost when tank is dropped, with exception of a few metal fittings.

After shaping from fiber and impregnated resin, tank halves are dried and molded under heat and pressure. Two halves are then riveted together over a gasket, baffle plates being fitted at same time. Following painting, tank is ready for service. Sizes are 50- to 180-gal. capacity.

A Method for Calculating Weights of New Flaps

By **JOHN B. SCALZI,** *Structural-Weight Engineer, Curtiss-Wright Corp.*

Based on structural considerations, this system affords notable accuracy by gaging contours of new components.

WEIGHTS OF FLAPS and of ailerons (designated here as flaps) may be estimated satisfactorily by using a value for weight per square foot of flap area obtained from previous airplane models.

But this method though rapidly and easily applied, is not necessarily conclusive. True, for new flaps that have materially the same magnitude of area and load as an old design, this method is acceptable. However, for new designs in which the geometry of the flap is different from any used before, a method of estimating the weight based on structural considerations is essential.

The two methods should serve as a check on each other, within reasonable limits of accuracy.

It has been determined that the material of a flap resisting bending loads consists of, (a) Upper and lower beam flanges combined with the effective skin at each flange, and (b) spanwise reinforcements and effective skin. (Material aft of rear spar is assumed ineffective). Typical flap cross-sections are shown in Fig. 1.

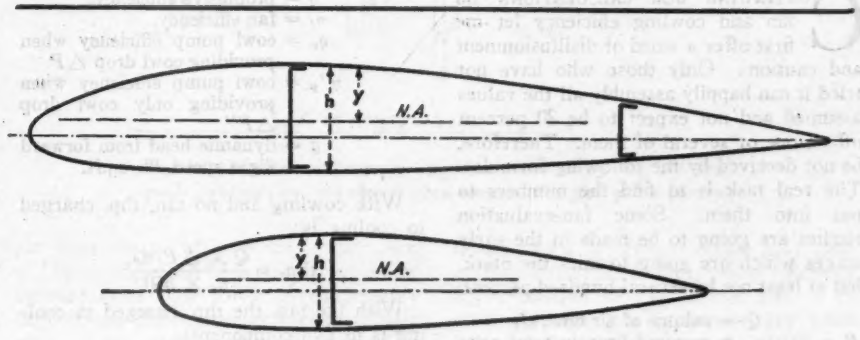


Fig. 1. Typical flap cross-sections.

Loads acting on the structure are a normal and a chordwise force with the accompanying torque forces. Total normal force is determined from the normal lift coefficient of flap, C_{Nf}, such that the total load acting normal to chord plane is—

$$N_f = C_{Nf}\, q\, S$$

where: N_f is total normal load, C_{Nf} normal lift coefficient; q dynamic pressure for max. flap speed, and S flap area.

The chordwise load is—

$$C_f = C_{cf}\, q\, S$$

where: C_f is total chordwise load, C_{cf} chord coefficient for flap, and q and S as above.

Maximum loads will occur when the flap is fully deflected at the maximum flap speed. It has been established that the chordwise moment will not greatly affect the design of the members, therefore the weight will not change appreciably by neglecting this moment effect.

Torsional load is carried by the torque box consisting of the skin and beams.

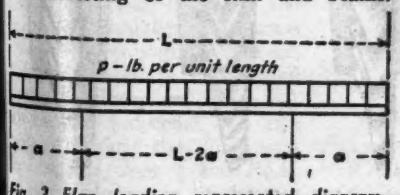


Fig. 2. Flap loading represented diagrammatically.

Experience has indicated that a skin selected as a reasonable minimum and contributing to resistance of bending loads will be satisfactory for torsional stresses. Therefore, the torsion load will not be considered directly as affecting the weight expression. The flap shall be considered to be designed entirely from the normal bending moment. A general expression for estimating the weight of the flap is derived for a two-support surface.

Derivation

Symbols: M is bending moment, p load per unit linear distance, L total length of flap, a length of overhangs (assumed equal), f allowable bending stress for beams, h total height of beam or average of two, y $h/2$, w unit weight per square foot, W flap weight (total), I moment of inertia of section, ρ weight per cubic inch of material, and k ratio of bending material to total weight.

Sketch of flap loading is shown in Fig. 2. The maximum moment at center of span, assuming uniform loading per linear inch of span, is:

$$M = \frac{pL}{8}(L - 4a)$$

The bending stress at the critical section may be computed by:

$$f = \frac{My}{I}$$

Assuming that $I = 2Ay^2$ for the section, then by substituting and rearranging terms, the area required to resist the bending load may be determined as follows:

$$A = \frac{pL}{8hf}(L - 4a)$$

Total flap weight $= k\,(2AL)\,\rho$

Substituting value for A:

$$\text{Total flap weight} = k\frac{pL^2\rho}{4hf}(L - 4a)$$

For convenience of the analysis it will be assumed that flaps and ailerons generally maintain a constant chord throughout their length. From a study of the spanwise distribution of load, it is reasonable to assume that average loading per square foot multiplied by the chord at each station will yield the loading per foot of length. This will be taken as a constant value for length of flap.

To facilitate the use of the equation, loading per unit length will be revised such that the load per square foot will be considered.

Letting: P = average load per square foot.
c = chord length (assumed constant).

Then: $p = Pc$

Substituting in the expression derived—

$$\text{Flap wt.} = k\frac{PcL^2\rho}{4hf}(L - 4a)$$

But: $A = Lc$ = total area of flap. The general expression becomes:

$$\text{Flap weight per unit area} = k\frac{PL\rho}{4hf}(L - 4a)$$

Simplifying the expression to eliminate all common constants—

$$w = k\frac{PL}{h}(L - 4a)$$

For a flap that has the supports at extremities, the following relation will be

(*Turn to page 277*)

Fan Cooling "Ups" Engine Performance

PART II

By **KENNETH CAMPBELL**, *Senior Project Engineer, Wright Aeronautical Corp.*

Proceeding from theory to practice, the author discusses various types of cooling fans used in his experiments.

CONTINUING OUR CALCULATIONS on fan and cowling efficiency let me first offer a word of disillusionment and caution: Only those who have not tried it can happily assembly all the values assumed and not expect to be 20 percent off on one or several of them. Therefore, be not deceived by the following formulas. The real task is to find the numbers to put into them. Some fan-evaluation studies are going to be made in the early stages which are going to miss the mark, but at least not by several hundred percent.

Q = volume of air flow, cfs.

$P = \Delta p/\eta_d$ = required drop in total pressure across entire ducting system, including engine and propeller-shank losses, lb./sq.ft.

Δp = engine baffle drop required, total pressure entering baffle passage to static behind, lb./sq.ft.

η_d = cowl duct efficiency; i.e., ratio of drop across engine alone to total pressure drop through entire cowling or ducting system.

$(P_1 - P_2)$ = pressure drop incurred between cowl entrance and engine face, lb./sq.ft.

$\Delta P'$ = fan boost (static pressure only) lb./sq.ft.

$\Delta P'' = \Delta P - (P_1 - P_2) - \Delta P' =$ portion of cowl drop ΔP which must still be provided by cowling when fan is helping, lb./sq.ft.

η = propulsive efficiency.

η_f = fan efficiency.

η_p = cowl pump efficiency when providing cowl drop ΔP

η''_p = cowl pump efficiency when providing only cowl drop $\Delta P''$

q = dynamic head from forward flight speed, lb./sq.ft.

With cowling and no fan, thp. charged to cooling is:

$$\text{thp}_c = \frac{Q \times \Delta P/\eta_d}{\eta_p \times 550}$$

With the fan, the thp. charged to cooling is in two components:

a. thp. taken from the propeller by the fan.

b. thp. due to deficiency of cowl exit velocity as in no-fan case, but reduced in magnitude

$$\text{thp. (fan)} = \frac{Q \times \Delta P'}{550} \times \frac{n}{\eta_f}$$

$$\text{thp. (cowl)} = \frac{Q \times \Delta P''}{\eta_p \times 550}$$

The difference between the cooling thp. for the no-fan and the fan cases is, then:—

$$\text{thp. gain from fan} = \frac{Q}{550}\left[\frac{\Delta p/\eta_d}{\eta_p} - \left(\Delta P' \times \frac{n}{\eta_f} + \frac{\Delta p''}{\eta_p''}\right)\right]$$

The gain may be made to come out a loss if low values of $\frac{\Delta p/\eta_d}{q}$ required are selected, combined with adverse values of fan efficiency.

In estimating the gain from a fan, the static-pressure boost should be used, not the total-pressure boost. Fig. 6* represents a typical nose fan installation. Bearing in mind that the engine fin and baffle passages constitute the air meter, the pressure differential which causes the required amount of cooling air to flow is the total entering the baffle passages (at all points) minus static pressure of the chamber into which the baffle orifices discharge. Cooling fan blades are necessarily short radially. Referring to Fig. 6, it is possible to achieve a high velocity impinging on the baffle entrances directly opposite the fan, and the flow in this region will benefit. But the lower half of the cylinders, and the crown fins of the head, cannot simultaneously be subjected to this velocity of approach. Unless there is conversion to static pressure after the fan,

* For Figs. 1 through 10, refer to Part I of this series, page 150 July AVIATION.

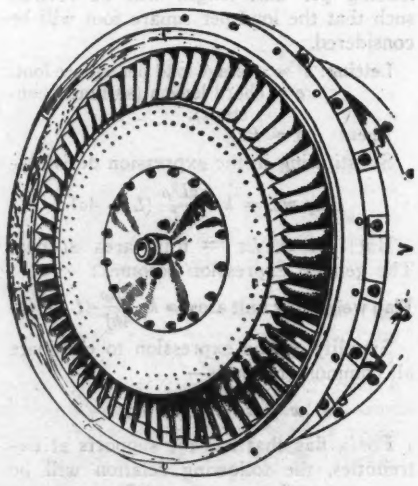


Fig. 11. Fan mounted for test in laboratory.

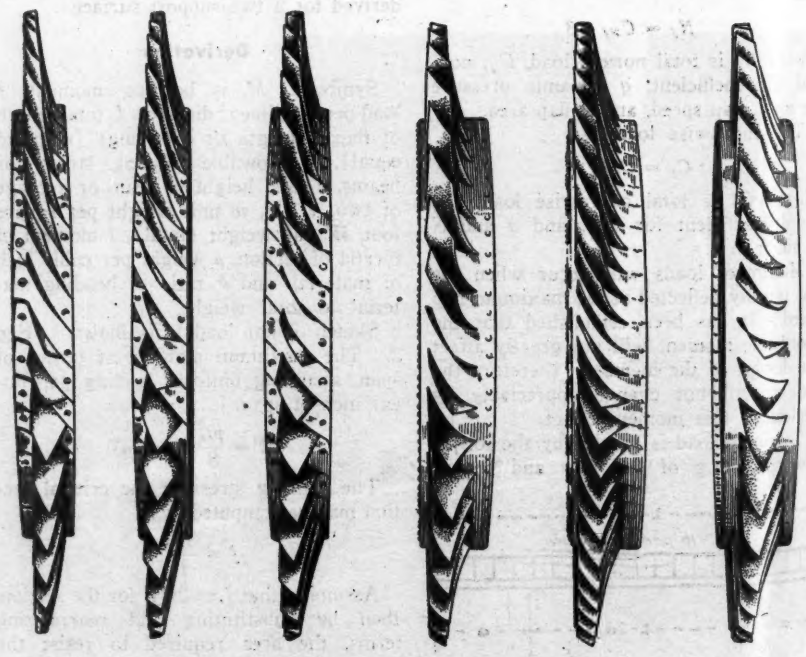


Fig. 12. Six 30-in. dia. fans as tested in laboratory, showing increasing boost from left to right.

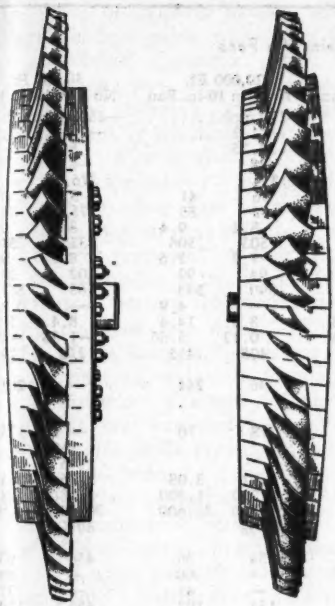


Fig. 13. Two 30-in.-dia. model laboratory fans; "Schichted" (right), not "Schichted" (left).

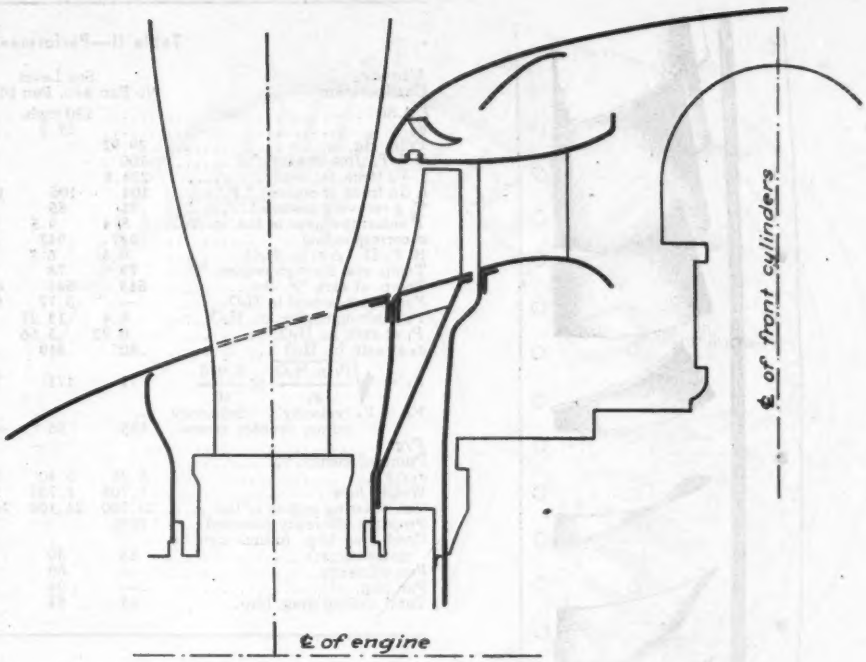


Fig. 14. Diagram of propeller-speed engine-cooling fan. At top, inside cowling line, are shown edge views of fan and guide blades.

any gain in pressure differential across at least half of the baffle passage area will be very small. Cooling will suffer, airflow will be below expectations—below that for which the fan was designed.

With the pusher or exit discharging fan, cooling air discharges at atmospheric static pressure. If, without fan or induced cooling, baffle pressure differential is sufficient for cooling the fan may be largely a velocity producer and still be fully effective. Otherwise, an increase in static depression behind baffle passages is necessary, and attainment of this is dependent on static boost of the fan.

Additional refinements can confuse the answer. One is the effect of heat energy. Just as the fan adds energy into the airstream, so does heat from cylinders, exhaust manifolding, or stacks. Rejection from cylinders is known over the mass flow, density, power, and mixture range. Not so the rejection from exhaust systems, disposed differently in each installation with respect to air flowing over them.

Gain from heat is simple enough: For prescribed mass flow, temperature before leaving exit opening is increased and, therefore, density decreased. With given pressure P_4 available to force air out exit to atmospheric pressure, acceleration of lighter air is higher, and velocity V_4 is higher. Since mass flow is, by cooling requirement, the same, mV_4 is higher and thrust deficiency $m(V_0 - V_4)$ at exit is reduced. The exit area to achieve the same mass flow at the same q and P_4 is, of course, larger in the heated-air case than with much cooler air.

The problem can be further complicated because mass flow for a given pressure drop across the engine declines materially with air temperature rise through the fins, and this occurs with variation in either altitude, power, or mixture variation to a varying degree, depending on the initial mass flow considered. This effect has been fully investigated.

Taking Fig. 1 and 3 the conditions of pressure, temperature, flow, and velocity at each strategic point in the system are calculated and final cooling thp. is arrived at arithmetically. However, in cases where ΔPq is greater than that permitting streamlined flaps, pump efficiency approximation of Fig. 2 still has to be used, although this is unnecessary when $\Delta P'q$ required is less than this value.

Table II demonstrates the procedure for a hypothetical case, last figures in columns representing thp. devoted to cooling in climb with and without fan at sea level, 20,000 ft., and 30,000 ft.

An important finding influencing design policy springs from many actual studies. There is a range of sea-level fan boost between 4 and 10 in. over which at normal values of cowl ΔP the net hp. devoted to cooling does not change to an important degree. With lower values of this boost range contributing large gains in performance up to intermediate altitudes from 25,000 to 30,000 ft. higher values of boost encountered with the same fan at sea level also give performance reasonably near optimum. This means that for this altitude range a controllable fan usually is not needed. This is not true for a useful 40,000-ft. fan, as indicated later. It should be obvious by now that requirements and variables are too vast to establish any specific altitude above which the manufacturer should provide a controllable fan.

In analyzing a specific airplane-engine cooling fan installation, the added weight of fan installation, and therefore a slight increase in airplane gross weight or hp. required to fly, must be taken into consideration. Propeller-speed fan installations will average an additional 40 lb. per

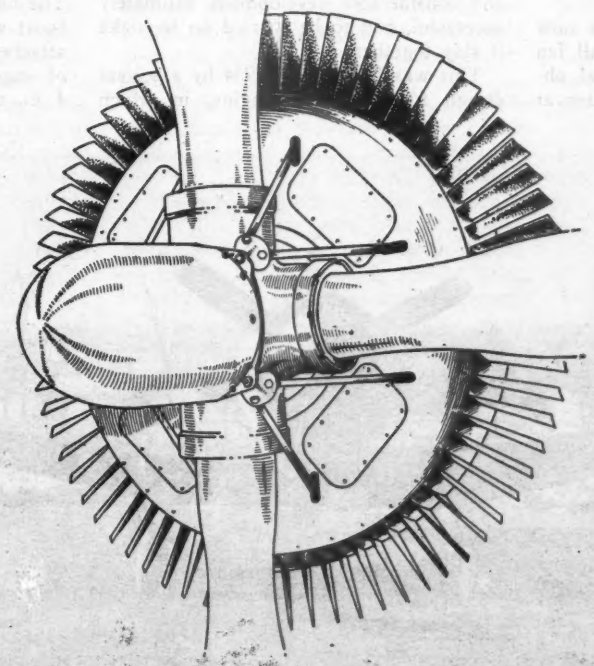


Fig. 15. Close-up of propeller-speed fan installed on propeller (used on Martin PBM-3D flying boat).

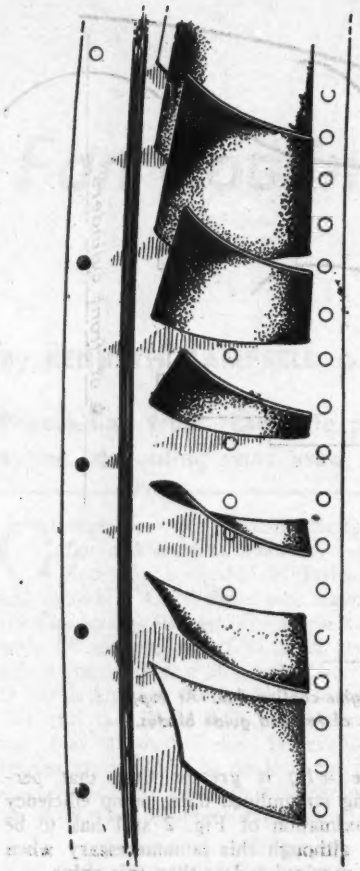


Fig. 16. Propeller-speed fan blade runner. Blades are made of sheet metal and have constant thickness.

Table II—Performance Gains Via Fans

Altitude	Sea Level			20,000 Ft.		30,000 Ft.	
Configuration	No Fan	4-in. Fan	10-in. Fan	No Fan	10-in. Fan	No Fan	10-in. Fan
I.A.S.	.....	150 mph.	.....	—150 mph.	.....	—150 mph.	.....
q	.....	11.2	.....	—11.2	.....	—11.2	.....
P_0 in. Hg	29.92			13.75		8.88	
O.A.T. (free stream) ° F	100			28		—8	
V_0 (true, ft./sec.)	228.5			314		376.5	
t_2 (in front of engine) ° F	104	106	109	36	41	3.4	8.4
% q recovery assumed	75	85	85	75	85	75	85
P entering engine or fan, in. H_2O	8.4	9.5	9.5	8.4	9.4	8.4	9.5
σ corresponding	.941	.942	.944	.503	.506	.356	.359
B. P. D. (Δp) in. H_2O	6.5	6.7	6.9	7.2	7.6	8.5	9.9
Temp. rise through engine, °F	79	78	77	94	92	102	99
Temp. at exit, °F. abs.	643	644	646	590	593	565	567
Fan boost, actual in H_2O	—	3.77	9.28	—	4.9	—	3.42
P_2 entering engine, in. H_2O	8.4	13.27	18.78	8.4	14.4	8.4	12.92
P_4 at exit, in. H_2O	0.92	5.56	10.84	0.12	5.66	−1.38	+2.37
σ_4 at exit, in. H_2O	.807	.819	.826	.405	.415	.270	.278
$V_4 = \sqrt{\frac{P_4 \text{ in. } H_2O}{\sigma_4}} \times \frac{3,970}{60}$	71	172	240	36	244	—	201
$V_0 - V_4$ (velocity deficiency, minus denotes excess)	158	56	−11.5	278	70	—	175
P/q						1.112	
Pump efficiency, %						21.5	
$\sigma_4 \Delta p$	5.25	5.40	5.56	2.92	3.08	2.36	2.50
Weight flow	1,705	1,735	1,760	1,220	1,300	1,080	1,125
Vol. entering engine or fan	23,700	24,100	24,400	31,700	36,600	39,700	41,000
Propeller efficiency assumed	70%			75%		80%	
Cowl drag bhp. (minus sign denotes thrust)	83	30	−6.2	134	36	456	93
Fan efficiency	—	60	60	—	60	—	60
Fan bhp	—	24	60	—	42	—	37
Total cooling drag, bhp	83	54	54	134	102	456	120

engine and approximately an additional 16 bhp. per engine in level flight. For geared fan installations, added weight per engine averages 60 to 80 lb. on a typical high-horsepower low or medium altitude installation, and 120 to 140 lb. for a high-altitude installation.

So much for the theory; let us now turn to practice: A relatively small fan boost was required for the original objectives, namely 3 to 4 in. of water at sea level, at rated rpm. As the cooling performance of engines was constantly improved through more and deeper fins and more technically correct baffling, thus greatly reducing baffle pressure drop, engine cooling kept pace with increased outputs of engines and the expected demand for fan assistance never materialized.

In 1932 a propeller-speed internal flow "spinner cowl" was built, and it completed a 50-hr. endurance test on a 650-hp. two-row engine, for which it was designed. This spinner-type fan took air through the nose, discharging axially from the rear of a spinner of a substantially larger diameter. Internal vanes were, of course, provided. The design turned out to be quite a severe structural problem, and considerable development, ultimately successful, had to be carried on to make it stay together.

This was followed in 1934 by a second design for the same engine, in which blades were put at the periphery of a smaller spinner. In many respects this fan resembles spinner fans of today and it was probably the first of this type; unfortunately, the blades were not designed aerodynamically.

In 1935 design studies were made of the pure centrifugal-blower type for a 750 hp. single-row radial engine, but the large inlet, structural complexity, and weight required for a strong enough blower of high capacity, coupled with desirability of a vaned diffuser outside blower, appeared discouraging, and the layouts were not released.

Next year a propeller-speed fan for a 9-cyl. 800-hp. radial engine was released, and in 1937 it was tested with the engine. Fig. 6 depicts this fan installed for test. The fan was designed to give 3 in. water boost at sea level at 2,300 engine rpm., attached to a propeller running at ½ of engine speed. Actually, the fan gave 4 in. under this condition. The blades

Fig. 17. Test airplane showing installation of propeller-speed fan with spinner.

were made of Micarta molded with an integral, oblique palm, which was bolted to two dished aluminum cones. The blade design was by the method of O'Brien and Gregory, except that the annulus swept by the blades was designed to decrease in area along the air path by virtue of the spinner's having a larger o.d. at the trailing than at the leading edge (this has subsequently been called "the Schicht principle" of design). The fan had 15 blades, 5 in. high, of RAF 6 section, 12 percent thickness ratio, and its tip diameter was 45 in. The low solidity of the fan was, by present standards, a mistake, although adequate for the requirement. The new cylinders for which this fan was designed cooled at very favorable baffle pressure drops, and there was no demand for the fan to meet the then-current objectives.

Later development was for an early model 2,000 hp. engine, in connection with protracted water takeoffs or slow single-engine climb. Calculations showed that a propeller-driven fan would be a much more difficult assignment, even for obtaining 4 in. of fan boost. The methods of blade design supposedly limited the boost which could be obtained for a given speed (pressure coefficient), and the inadequacy of the method for obtaining high pressure coefficients was not yet appreciated. The propeller speed was only $\frac{7}{11}$ of engine speed, as compared with $\frac{1}{2}$ in the case of the 9-cyl. engine. Further, flow volume was nearly doubled, diameter remaining unchanged, necessitating higher pitch angles and more critical fan performance. Speeding up the fan would overcome this difficulty. Thus, in 1939 a geared fan was designed, and it was tested on a running engine in 1940 (Fig. 7).

This fan had several novel structural features of interest in connection with today's geared fans. It ran at crankshaft speed by means of a planetary step-up gearing surrounding the propeller shaft in the nose. As before, the blades were made of formed Micarta terminating at the root in an integral projecting block, suspended centrifugally within two forged steel rings. The fan gave 4 in. of water additional boost on the front of the engine at 2,400 rpm., meeting requirements.

The next fan built was for 40,000-ft. altitude performance, for a subsequently canceled project initiated in 1941 and completed in 1942. Recognizing that the entire ΔP need not be provided by the fan, a 40,000-ft. boost of 5 in. of water at 80,000 cfm. was chosen, which, without controllable features, reflects over 300 hp. at sea level. An extensive fan and drag evaluation study at varying boosts over the altitude range from sea level to 40,000 ft. showed that if the fan boost could be reduced to 50 percent at sea level without impairment of efficiency, no further gain in performance would accrue from further boost reduction at the lower altitudes.

Since vanes counter to the fan rotation were considered desirable to increase boost at altitude, it was decided to make these

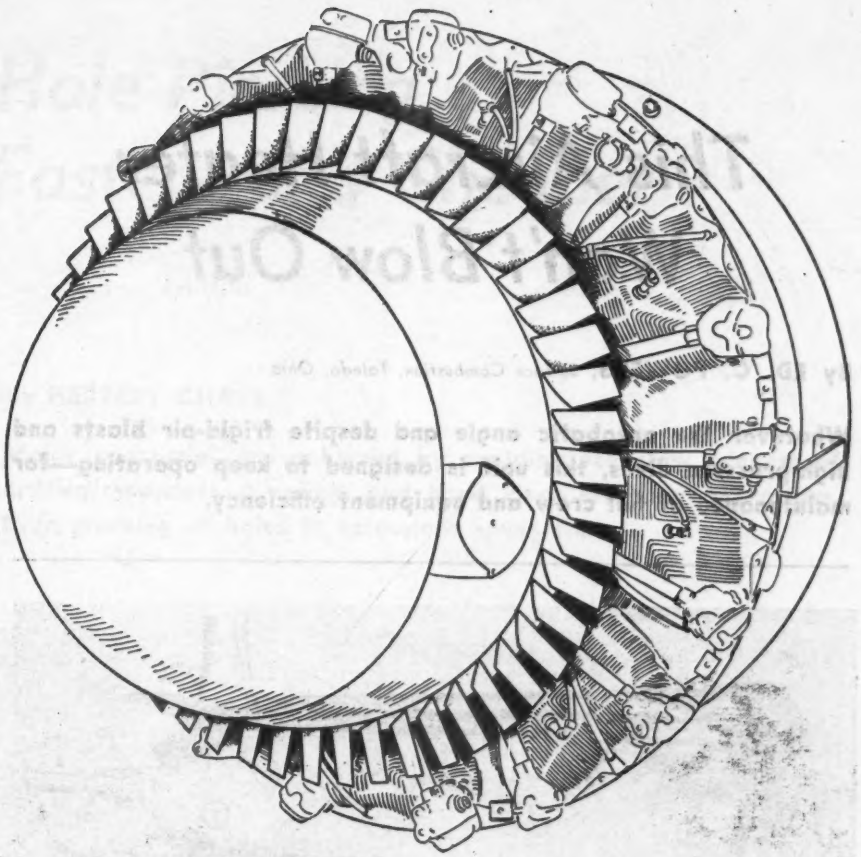


Fig. 18. Propeller-speed cooling fan rotor with spinner, shown mounted on engine for test.

ahead of the fan and controllable, so that at low altitudes they could be twisted in the direction of fan rotation. Fig. 8 is a photograph of the completed assembly on an engine, and Fig. 9 is of the fan rotor proper. The pre-twisters are adjustable from 45 deg. counter to 45 deg. with rotation. The pre-twister assembly, including blades, is cast magnesium, and the fan blades are again Micarta, per Keller method, installed as previously described, though shorter and more closely spaced.

The Schicht theory claims that the breakaway from the blades of a Keller designed airfoil fan at high attempted pressure coefficients can be eliminated by not permitting the relative velocity w (Fig. 10) through the blades to slow down as it normally must do according to the geometry. Instead, Schicht holds that w_2 leaving the blades should be maintained equal to the entrance value w_1 by

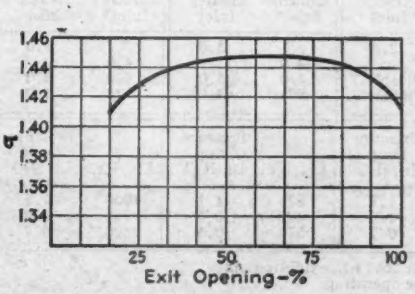


Fig. 19. Data obtained from Wright Aeronautical Corp. experimental test plane with propeller-speed fan.

reducing the radial height of the blades along the path.

Then, says Schicht, the lift coefficient or curvature of the blades can be enormously increased and more energy can be put into the air without separation. As the velocity diagram indicates, this means that virtually all the energy appears as velocity C_2, and if static pressure boost is desired, efficient diffusion must follow, as in supercharging. For our purpose, then, if some "Schichting" is found necessary, its degree should be compromised with the pressure coefficient (boost for a given speed) and static pressure boost planned. We have since found that a small degree of "Schichting" goes a long way, if done properly.

In 1941 Dr. Frank Wattendorf published a short treatise on fan blade design in which, even without "Schichting," he demonstrated actual test points which reflected, again on a total-pressure basis, pressure coefficients substantially higher than the Keller limitations imply can be obtained in a single axial fan stage. Keller finds that the minimum spacing of blades must not reflect a chord/pitch ratio of over 1.1 and, simultaneously, that the maximum lift coefficient expected of airfoils must not be over 1.0 on an infinite-aspect-ratio basis. Watterdorf found he could go to chord/pitch ratios of at least 2.0 (we have since found that this depends a good deal on the entering blade angle and pressure coefficient) by lining up the leading and trailing edges of the blades with the entering and leav-

(*Turn to page 297*)

This Aircraft Heater Won't Blow Out

By **ED. C. POWERS,** *Surface Combustion, Toledo, Ohio*

Whatever the aeobatic angle and despite frigid-air blasts and high-pressure dives, this unit is designed to keep operating—for maintenance of full crew and equipment efficiency.

WHEN HIGH-ALTITUDE FLYING suddenly passed from the experimental to the routine stage at the beginning of the war, the air forces needed a compact heater that could be relied upon to combat severe stratosphere cold. It had to weigh less than 25 lb.

Air at 30,000 ft. is so thin that nothing will burn there in conventional fashion because of insufficient oxygen. To promote combustion, a surplus of air must be crammed into a small space, as in the cylinder of a supercharged engine. While this problem was being solved, it was remembered that the heater also had to operate at ground level, be capable of being lighted in a blast of frigid air, stay lit in a long dive when the air pressure suddenly builds up to five times what it was, and operate unfailingly at slow as well as high speed and at any angle.

The Janitrol aircraft heater was developed by Surface Combustion engineers to meet these requirements. This heater operates on the principle of a whirling flame, produced by introducing air into the cylindrical combustion chamber tangentially to its inner surface. It is now being installed in such planes as the Douglas C-54 *Skymaster,* North America's B-25J *Mitchell,* Curtiss-Wright's C-46 *Commando,* the Douglas A-20 *Havoc,* the new Budd RBI *Conestoga,* the Grumman TBF *Avenger* the Douglas SBD *Dauntless,* the Canadian Vickers PBV *Canso,* the Northrop P-61 *Black Widow,* and others.

Ignition is continuous because the flame

(*Turn to page 264*)

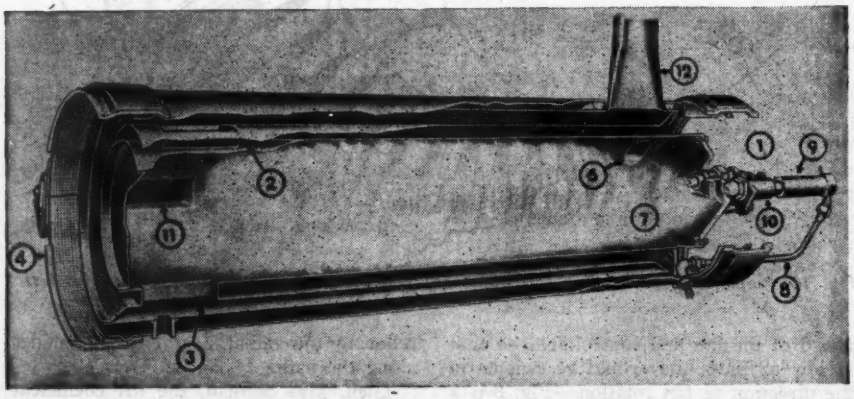


Fig. 1 illustrates principle of operation. Ram air enters at (1), blankets combustion tube (2) and heat exchangers (3), then is heated and discharged through (4) into distribution system. Some air passes through (6) into combustion chamber (2) tangentially to create whirling action which picks up vaporized fuel (7) to form air mixture. Liquid fuel enters by (8) through preheater (9) and spray nozzle (10). Hot combined gases enter secondary heat exchanger (3) via openings (11) and are exhausted through flue (12).

Table I—Performance of Vaporizing Models

(With Standard Air at 29.92 In. Hg. and 59 Deg. F. 87–100 Octane Aviation Gasoline)

	15,000 Btu.		40,000 Btu.		50,000 Btu.	
Btu. output per hr.	15,000		40,000		50,000	
Gasoline lb. per hr.	1.2		2.8		3.6	
Gasoline pressure psi (at regulator inlet)	5.0–25.0	0.8–1.2	5.0–25.0		5.0–25.0	
Combustion air, lb. per hr.	24.7		57.5		71.5	
	Min. Combustion Air Pressure Diff. In. H_2O Required Across Heater					
Combustion air regulation types	Control Inlet*	Heater Inlet	Control Inlet*	Heater Inlet	Control Inlet*	Heater Inlet
No combustion air regulation**	...	2.0	...	3.0	...	3.0
Relief dump valve	3.0	...	4.0	...	4.0	...
Differential regulator	Not applicable		4.0	3.0	4.0	3.0
Aneroid, used with diff. reg.	Not applicable		***	3.0	***	3.0
Ventilating air (59°F.—29.92 In. (hg.)	Lb./Hr.	Pressure Drop In. H_2O	Lb./Hr.	Pressure Drop In. H_2O	Lb./Hr.	Pressure Drop In. H_2O
Temperature rise 200°F.	313	1.7	875	1.1	1000	1.5
Temperature rise 250°F.	250	1.2	690	0.8	745	0.9
Temperature rise 300°F.	208	0.9	570	0.6	590	0.7

Current consumption glow-plug ignitor 10–14 amp., 26v. while lighting only.
Magnetic fuel valve—approximately 1.0 amp. while operating.

*No allowance for drop between control outlet and heater or beyond heater exhaust connection.
**Heated ventilating air pressure must be engineered to maintain minimum combustion air pressure.
***Inlet pressure determined on specific application.

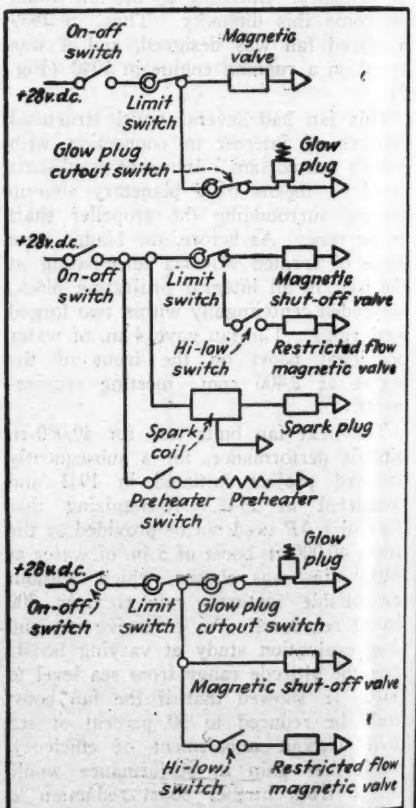


Fig. 2. Electrical circuit diagrams. Left, with glow plug; center, with preheater; right, with hi-low regulation.

Hole Piercing Proves Faster—and Cheaper

PART II

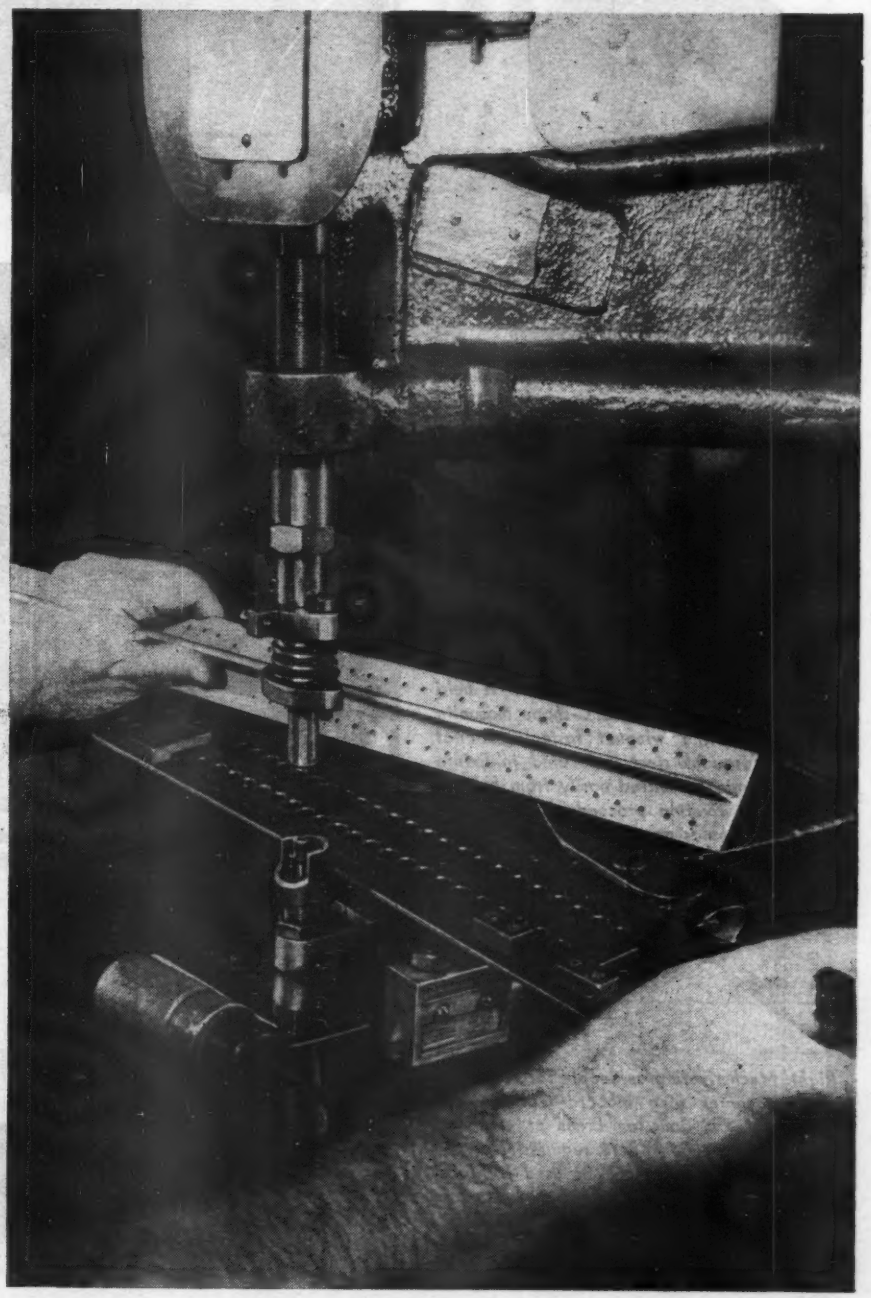
By HERBERT CHASE

Major economies are achieved by avoiding the slow process of drilling, separate dimpling, and hand rivet insertion operations. Even piercing of holes in extrusions saves time.

IN THE FIRST ARTICLE of this series it was explained how Glenn L. Martin Co. gets significant economies by (1) punching (piercing) rather than drilling rivet holes, and (2) by use of automatic machines that insert and drive the rivets.

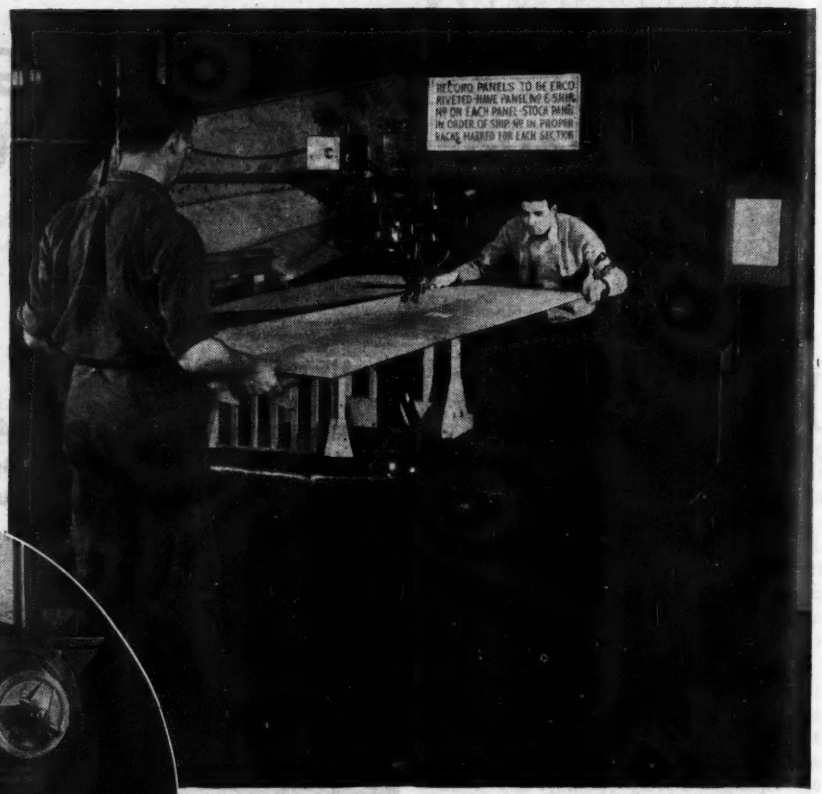
Wherever possible, the whole sequence of operations, including dimpling, when required, is performed in Erco machines. Small to medium sized assemblies, are handled along belt conveyor lines as previously described.

For larger assemblies and extrusions (dealt with here) the same basic methods are applied, but even greater economies are realized, since the number of rivets per piece is larger. Because of the sizes of the parts and assemblies, however, handling methods are different. In some cases, a "beam" Erco machine, having a box-like frame is employed in preference to an open-throat machine with C-shaped frame. Different methods of supporting the work are used. For the largest assemblies, no jigs are required. The accompanying illustrations show how the assemblies are made.

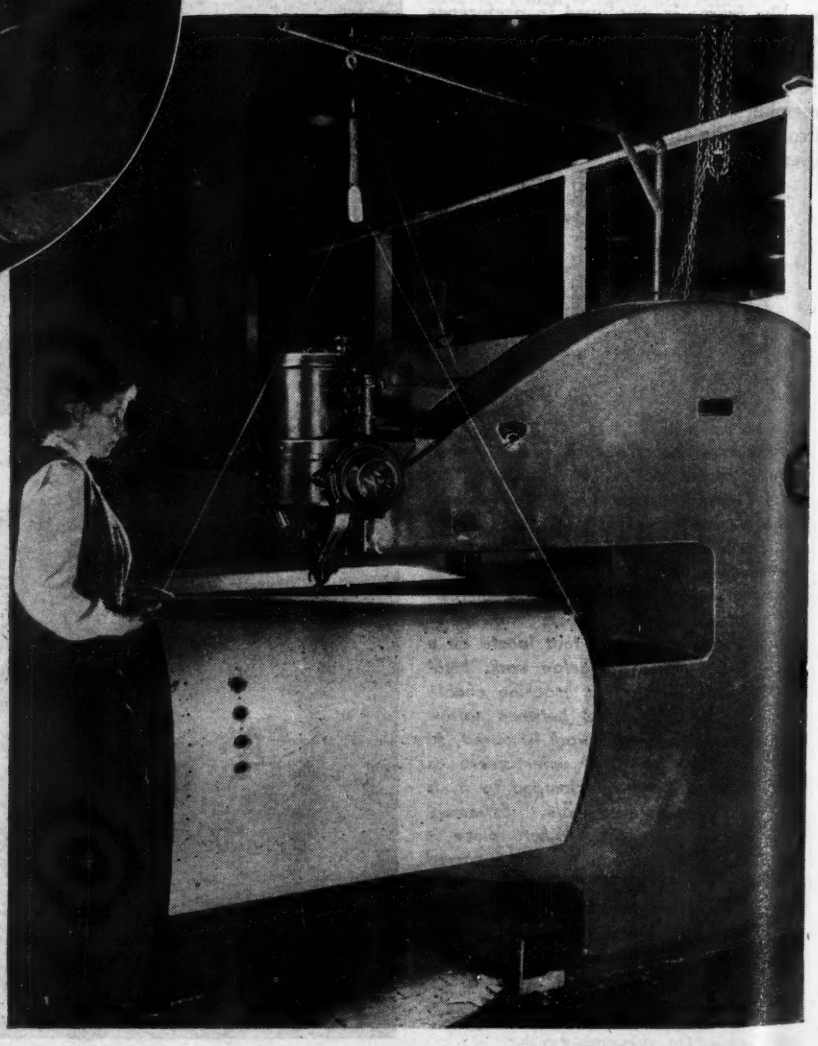


Stringer extrusions and rolled sections of similar shapes that cannot be Ercoed (usually because assembly to mating skin or web elements does not take place until part is being built into a unit that cannot be handled through a machine) have rivet holes punched in this Tubular piercer. Templates, most of which are long, are of sheet metal with holes that locate on a sleeve surrounding die below work. Light and mirror in front of machine enable operator, who is seated between narrow roller tables on which work is moved, to see locating holes and enter sleeve as template, with worked clamped to it, is shifted from hole to hole. Extremely rapid piercing results. Where piece is curved, jig as well as work are curved during piercing, avoiding dimensional variations. Curved templates and work are supported by slings rather than roller tables.

Right: Many large PBM Mariner skin panels are riveted in about one-fourth former time on this beam-type Erco. In most cases, work consists of attaching stringers requiring long rows of rivets. Usually, parts are first Clecoed, using just enough fastenings to hold them in position until a few rivets can be applied. Straight edge of stringer generally serves as a guide to keep rivets in straight line. One-man operation is achieved by having work supported by slings from rails so arranged that it is easily moved longitudinally or transversely to bring it into position for each rivet.


RECORD PANELS TO BE ERCO
RIVETED NAME PANEL NO E SHIP
NO ON EACH PANEL STOCK PANEL
IN ORDER OF SHIP NO IN PROPER
RACKS MARKED FOR EACH SECTION

Above: In this Erco machine, clips of 0.051-in. stock are riveted to 6-ft. long Z-section extrusions 0.130 in. thick. Clips are positioned in slots and against stops in masonite fixture and Z-section is held against clips by hinged C-shape masonite blocks having wingnut fastenings. Pilot hole for each rivet is located in fixture base, which is shifted easily from hole to hole as riveting proceeds. Thus fixture not only holds part in correct position but acts also as a jig.



Right: Much riveting on deeply formed parts, such as center wing inboard leading edge shown here, is done on Ercos at comparatively high speed. Where required, sprayed spots and light beam can be used for location, but operators accustomed to job locate work by eye with satisfactory results. Handling is facilitated by supporting work from a sling, as shown.

Load Characteristics Of Cellulose Acetate Plastic

PART III

By WILLIAM N. FINDLEY,
Assistant Professor of Theoretical & Applied Mechanics, College of Engineering, University of Illinois

Completing this valuable series, the author discusses the effect of range of stress and results of experiments to determine the action of time and creep.

ALL OF THE previously mentioned endurance limits were obtained for completely reversed stress cycles. It was known that the resistance to repeated loading was influenced by range of stress, so it seemed desirable to study the effect of this variable.

Range of stress will be defined in terms of two quantities. A cycle of stress may be resolved into two components, a constant or mean value of bending stress, σ_y, and an alternating stress, σ_a, which is superimposed on the mean stress. For the previous set of tests, mean stress was zero, and the endurance limit was the magnitude of the maximum alternating stress which would not cause fracture after a large number of cycles. When the mean stress is not zero, the corresponding value of maximum alternating stress, σ_a, which will not cause fracture is here defined as endurance limit of the material for that value of mean stress. In Fig. 15 maximum stress of the stress cycle for various values of minimum stress of the cycle is plotted against the number of cycles required to cause fracture. Maximum stress was found to increase with increase in mean stress. However, when the endurance limit was plotted against mean stress for different ranges of stress the diagram (Fig. 16) was obtained which shows that endurance limit decreases with an increase in mean stress of the cycle, when mean stress is tension. The ranges of stress shown are for tension mean stress, since it was revealed that fatigue fracture originated on the tension side of the specimen.

It was found that during the test of a specimen mean stress of the cycle decreased very rapidly during the first million cycles (at a speed of 1,750 cycles per minute). Thereafter mean stress decreased very slightly with increase in number of cycles. This decrease in mean stress was due to relaxation as a result of creep under the action of mean stress. In order to evaluate the effect of this relaxation on the diagram (Fig. 16) the value of alternating stress and mean stress which obtained at one million cycles was plotted as open circles. It was found that relaxation of stress did not materially affect the endurance limit-vs.-mean stress

• For data on properties of commercial plastics, see Engineering Data Book, page 203 this issue.

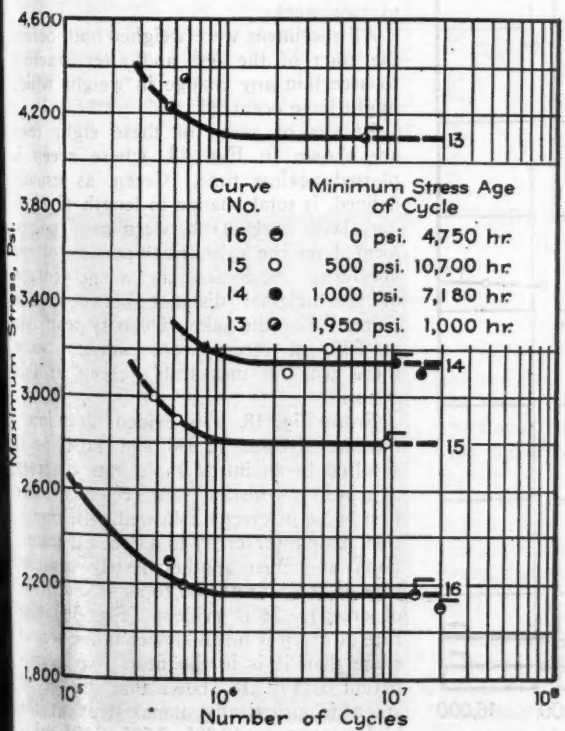


Fig. 15. Several different ranges of stress, as shown on Σ-N diagram.

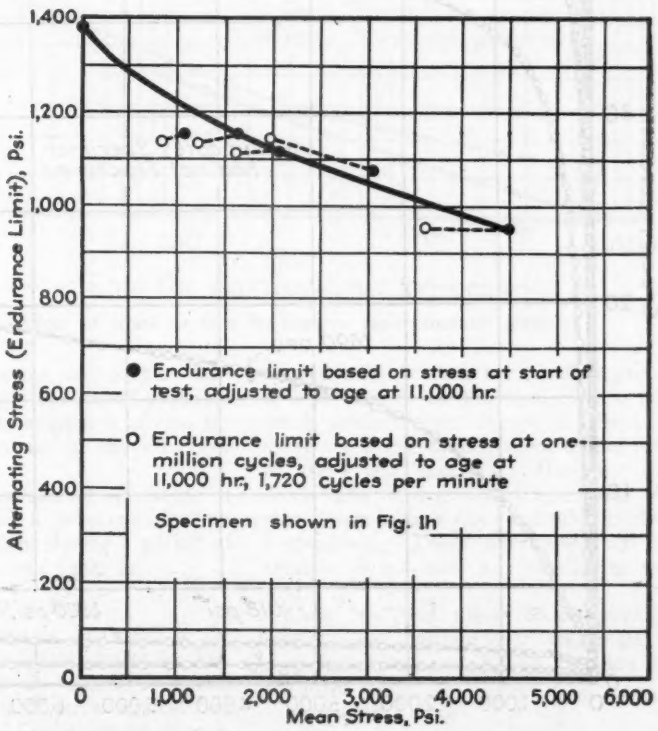


Fig. 16. Effect of mean stress on endurance limit for different ranges of stress.

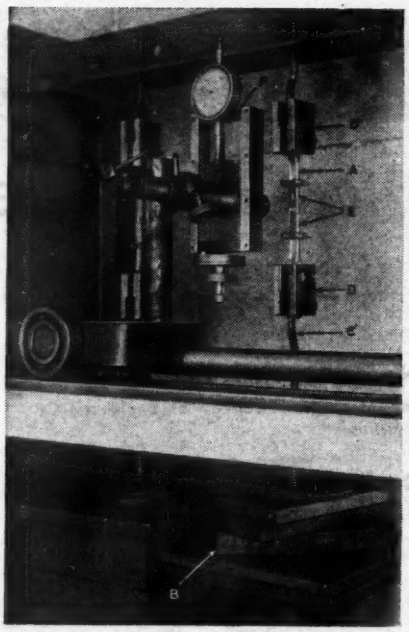


Fig. 17. Creep testing equipment. A is test specimen, B dead weights which impose tensile stress, C rod carrying weights, D grips with swivel joint, E T-shaped brass strips of extensometer, and F cathatometer or traveling microscope for measuring stretch of specimen.

diagram. Data plotted in Fig. 16 were adjusted to an age of 11,000 hr.

Equipment for creep tests consisted of a steel rack from which 24 specimens could be suspended, calibrated weights used for loading specimens, measuring equipment for determining strain in each specimen, and a clock equipped with a counter to record elapsed time in hours.

Fig. 17 shows a portion of the creep rack with apparatus set up for measuring strain of a specimen. The specimen was similar to tension specimen, Fig. 1c, except that the width of the test section was 0.31 in. As may be seen, specimen *A* was subjected to an axial tensile load by means of dead weights *B*, attached to the rod *C*. The specimen was held by grips, *D*, which contained a hook-and-eye type of swivel joint. This joint was provided in order to minimize possibility of bending the specimen.

The extensometer for measuring creep consisted of two T-shaped brass strips, *E*, clamped to the specimen with a traveling microscope (cathatometer *F*) for measuring displacement between fixed reference marks on ends of the two brass strips.

Brass strips *E* were clamped to the specimen with compressed springs in order to keep the extensometer firmly attached to the specimen during the test, since a reduction of area of 30 percent might be expected before fracture took place.

Measured distance between centers of the flat bars, to which the springs were attached, was considered to be the gage length of the extensometer. This was 2 in. at the start of the test.

Tests were started with eight specimens at the same time, but with different stresses ranging from 505 to 2,695 psi. Procedure in starting these tests was as follows:

Weights, from 30 to 150 lb., were first supported on planks, blocked up in such a way that they could be used as levers to lower the weights quickly but gently until they were supported by the specimen. Before lowering the weights, initial extensometer readings were obtained with the traveling microscope. Then the weight was lowered on the first specimen, the extensometer was immediately read again, and the time was recorded. The difference between the strains computed from these two sets of readings was the elastic strain. Any further increase in strain was the result of creep. The remaining seven specimens were treated in the same way.

After all eight tests had been started, strain and time readings were taken at intervals, which for the high stress tests were from 2 to 12 hr. until fracture. Low stress specimens were read about every two days for a month, then every one to two weeks.

All specimens were weighed both before the start of the test and after fracture to ascertain any change in weight which might have occurred.

Results of seven of these eight tests are shown in Fig. 18, where creep is plotted against time. Creep, as usually defined, is total change in length (including elastic stretch) between gage points, located on the cylindrical portion of the specimen, expressed as a percentage of the original distance between gage points. For the sake of clarity test data at 505 psi stress were omitted, since there was no measurable creep at this stress.

From Fig. 18, it is evident that intermediate stresses (2,008 and 1,690 psi.), resulted in an initial rapid rate of creep at a nearly constant rate (referred to as first stage of creep) followed by a transition region (referred to as second transition) and then another nearly constant rate of creep (referred to as second stage of creep). It is evident (Fig. 18) that rate of creep is much slower in the second stage than it is in the first. An examination of Fig. 18 shows that the second stage is practically nonexistent at the higher stresses (2,305, 2,505, 2,695 psi.). Also for the low stresses (1,018 and 1,320 psi.) the second stage either is

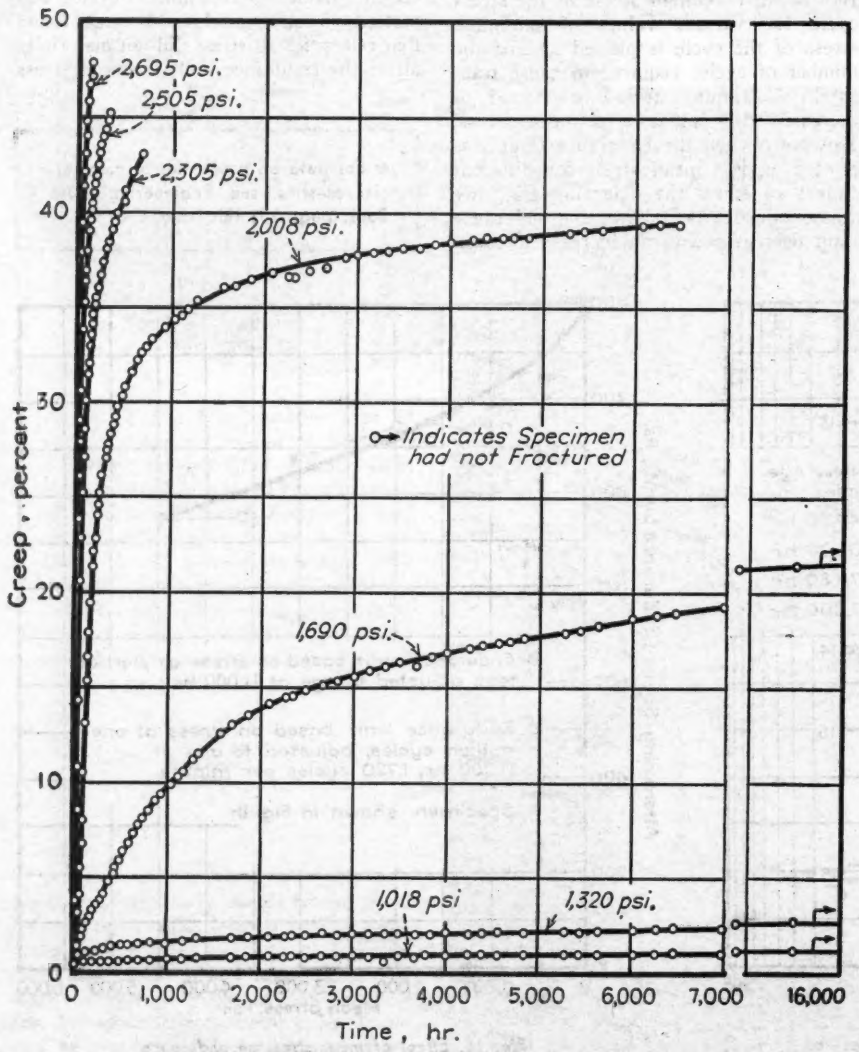


Fig. 18. Creep vs. time diagrams for several stresses.

nonexistent or had not yet been reached after 7,000 hr. of testing.

When the data was plotted to a larger scale, an initial or first transition region was found preceding first stage of creep. Curvature of this transition was concave downward for intermediate and low stresses and concave upward for high stresses.

It was noticed that no final region of increasing rate of creep occurred, such as the "third stage" of creep in metals. This is probably because there is no localized reduction of area (necking down) just before fracture of this material, as there is for metals.

After an elapse of 2,330 hr. (about three months) from the start of these tests two more specimens were started at 1,802 and 1,900 psi. in order to obtain more information at intermediate stresses. The rate of creep of these specimens was much lower than was to have been expected on the basis of the first tests.

The difference in behavior of these two sets of tests can only be the result of elapse of time between the start of the first tests and that of the second (aging) because all other conditions were held constant. All specimens were made at the same time from the same sheet of acetate, and they had been in the air-conditioned laboratory for the same period. By aging is meant a change in mechanical properties with time. Possible causes might be: Slow change in moisture content, residual solvent content or plasticizer, or perhaps further polymerization.

In order to study this phenomenon further, tests of the remaining two specimens were started 5,260 hr. after start of the first test, at stresses of 1,690 and 1,900 psi. The specimen used for the first test at 505 psi. was also changed to a stress of 2,305 psi. (The specimen had not shown any creep at the 505 psi. stress.)

It was noticed that the rate of creep for these tests was much less than that for the first group but was greater than the rate of creep for the second group of specimens. No explanation is offered for this apparent reversal in the effect of aging.

Weight measurements of specimens of the acetate showed a decrease of about 0.6 percent in weight during a period of creep testing of about 7,000 hr.

Fig. 22. Fractured specimens. Left: Circular cross section fatigue specimen. Center: Tension specimen. Right: torsion specimen.

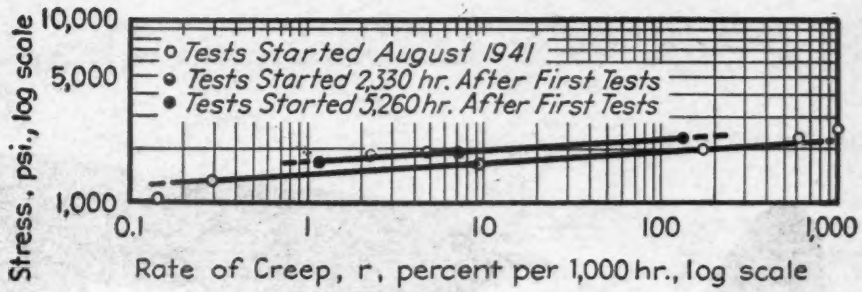


Fig. 19. Log-scale diagram showing effect of stress on rate of creep.

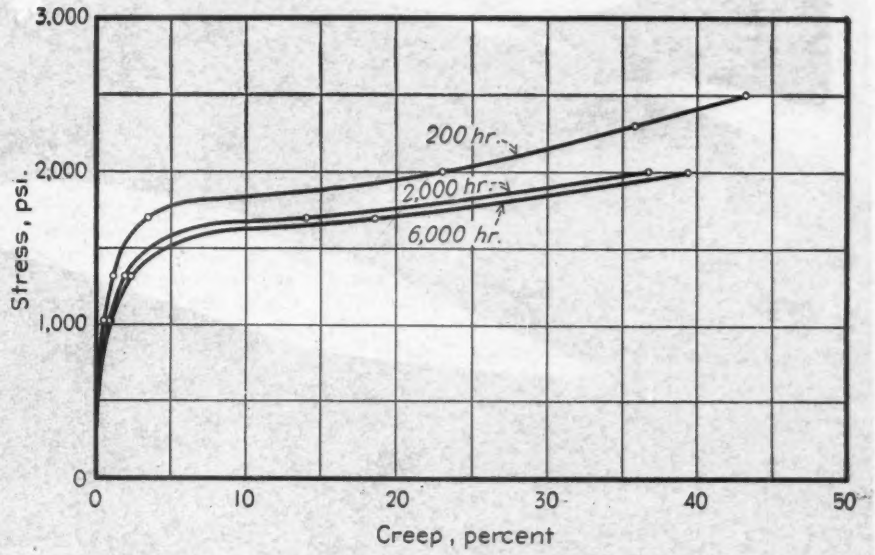


Fig. 20. Effect of stress on creep for three different time intervals.

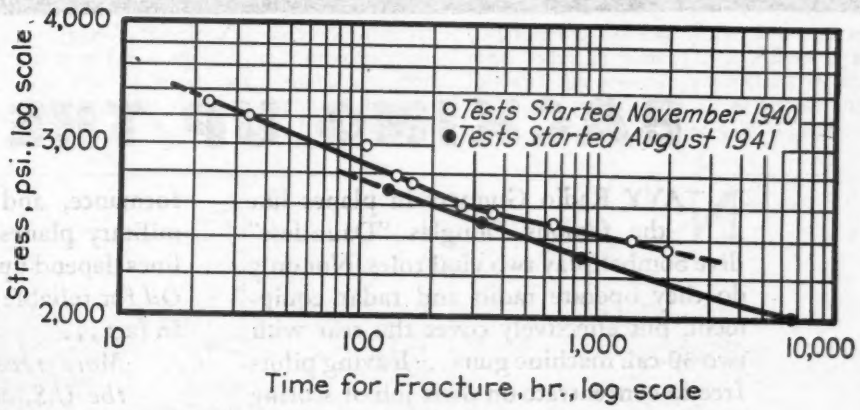


Fig. 21. Effect of stress on time for fracture under constant load.

Effect of Stress

Influence of stress on the creep of the cellulose acetate is better shown by Fig. 19 and 20. Fig. 19 shows a double logarithmic plotting of stress against rate of creep (for the first stage of creep). The rate of creep is obtained as the slope of the curves shown in Fig. 18 for the first stage, as defined above. It will be noticed that the data for the first group of tests, shown by the open circles, fall on a straight line, except at the two extremes where measurement of the rate of creep was uncertain. Data for the second and third groups of specimens are also shown by half-filled and filled circles, respectively. These data also fall on straight lines which are parallel to the first.

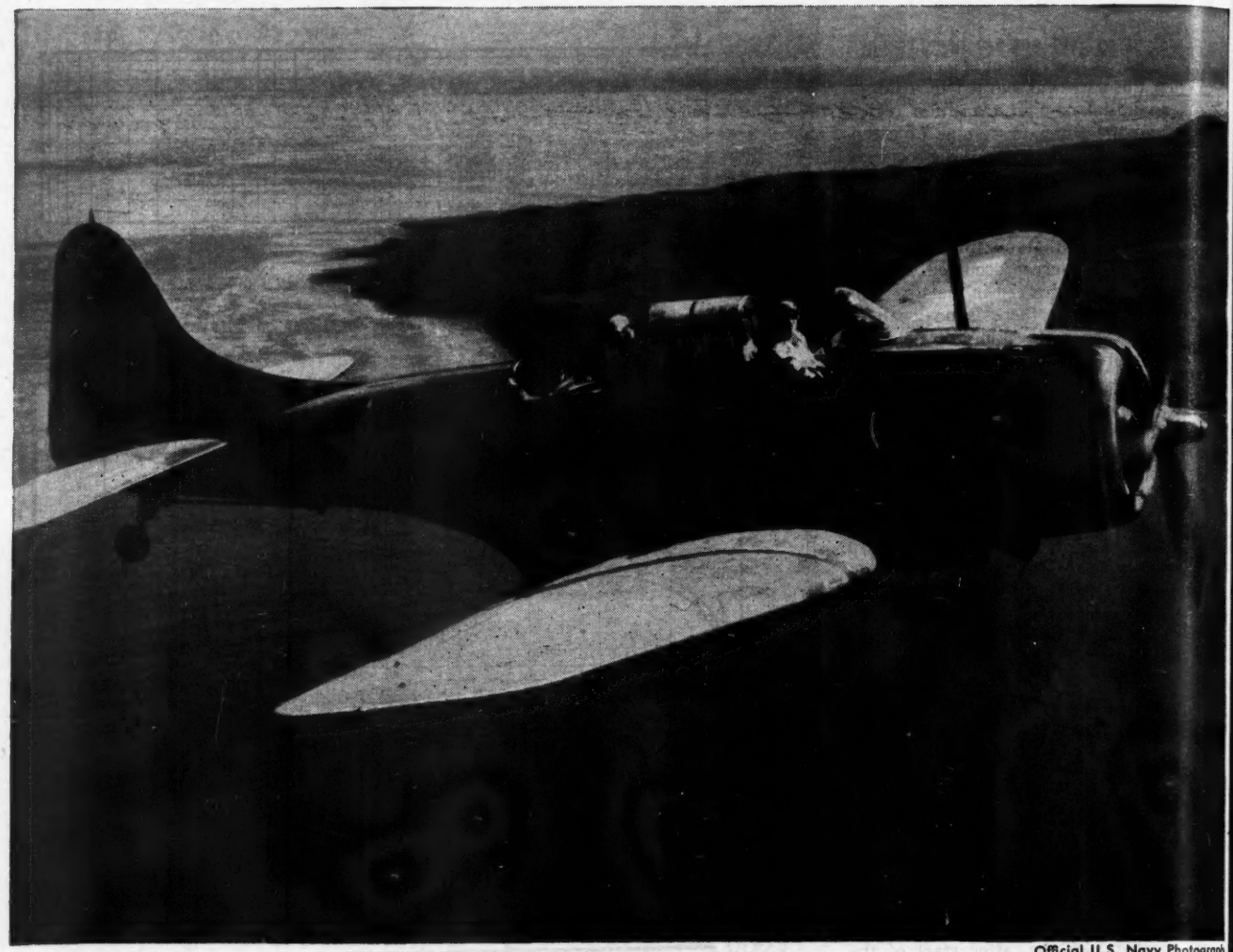
Data, such as these, which yield a straight line on double logarithmic plotting may be represented by an equation of the form—

$$\sigma = m.r^n$$

where:

σ = stress,

(*Turn to page 260*)



Official U.S. Navy Photograph

BACKING UP THE PILOT

NAVY Radio Gunners in planes like the famous Douglas "Dauntless" dive bomber play two vital roles. Not only do they operate radio and radar equipment, but effectively cover the rear with two 30-cal. machine guns . . . leaving pilots free to concentrate on their job of scoring direct hits.

The skill and daring of these Navy Radio Gunners is largely responsible for the destruction of hundreds of enemy planes and ships.

The success of a plane depends not only on its crew, but on faultless engine performance, and thousands of engines in military planes as well as in civilian airlines depend upon *Texaco Aircraft Engine Oil* for reliable and economical operation. In fact . . .

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FOR THE AVIATION INDUSTRY

TUNE IN THE TEXACO STAR THEATRE EVERY SUNDAY NIGHT — CBS ★ HELP WIN THE WAR BY RETURNING EMPTY DRUMS PROMPTLY

How to Look After Those Aerols

By EDWARD E. THORP

With today's multi-ton airplanes hitting the runways at up to 200 ft. per second, the mechanism that absorbs the jolt demands the highest type of careful attention.

THOUGH MOST MECHANICS are familiar with the general construction of Aerols, the precise method whereby they absorb landing shocks is not so well understood.

Three models—typical of those used on most planes—are shown in Figs. 1, 2, & 3. They all operate on the same principle (compression of air in the head and resistance of fluid to passage through a restricted orifice) except that one of the smaller types uses a spring instead of compressed air.

Referring to Fig. 4, which illustrates the Cleveland Pneumatic Tool Co.'s ten models, it will be seen that some are cantilever—that is, they carry all ground loads in addition to the weight of the plane—while others are compression only, with simply the weight of the machine carried by the Aerols, other stresses being taken by the framework of the landing gear.

Type I is a basic design, typical of all Aerols. Orifice plate (15) allows a constant flow of fluid between chambers *A* and *B* during operation. On impact, piston (3) moves into cylinder (1), forcing fluid out of *B* through orifice (10). This action absorbs most of the impact energy of landing and is dissipated as heat. The fluid compresses the air in the upper chamber until combined pressure and oil resistance equals the weight of the plane or impact resistance. As the impact decreases, the air pressure causes the Aerol to extend, drawing the fluid back into the lower chamber *B*. This movement continues, decreasing in amount until the piston comes to rest (static position).

Type II functions in the same manner as type I, but added to it is a recoil valve (*b*, Fig. 5) which has a snubbing action on the return stroke of the piston by permitting the fluid to return only through the small hole in the valve plate, thus changing oscillation periods and reducing time required to come to rest.

Type III differs from the last design by having a metering pin (*C*, Fig. 5) which partly closes orifice plate, thus automatically controlling fluid flow during the stroke of the piston. This action also serves to dissipate the greatest amount of impact energy.

Type IV has the same action as type III but features addition of a plunger tube (17) which suspends the orifice plate in the piston, to shorten over-all length.

Type V has no metering pin but is equipped with a recoil valve (4) giving the same snubbing effect as type II.

Type VI is similar to type V with addition of a metering pin.

Type VII has the same action as type VI except that here the relief valve is located in plunger tube (17).

Type VIII functions like type VII, but it has no plunger tube, the relief valve being located on recoil tube (19).

Type IX has the same action as type IV, but it differs in that this design incorporates a floating head (24) and oil relief valve in plate (15). Effect is as follows: Air pressure is not effective during whole stroke, since air is carried only above head (24). After head (24) con-

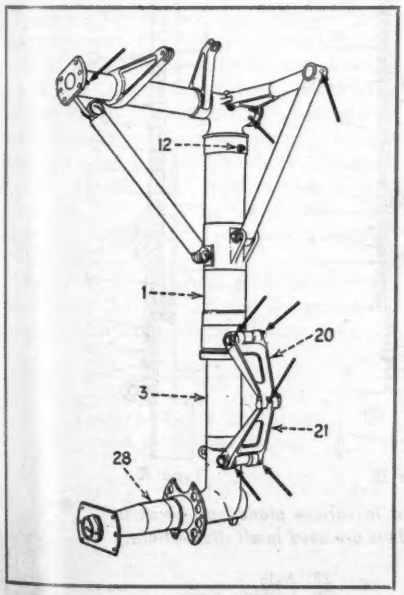


Fig. 1. Here, main Aerol lubrication points are shown by heavy arrows. On landing, piston (3) telescopes into cylinder (1) forcing oil in (1) through opening into top and compressing air there. All parts are identified in list below Fig. 4 (opposite page).

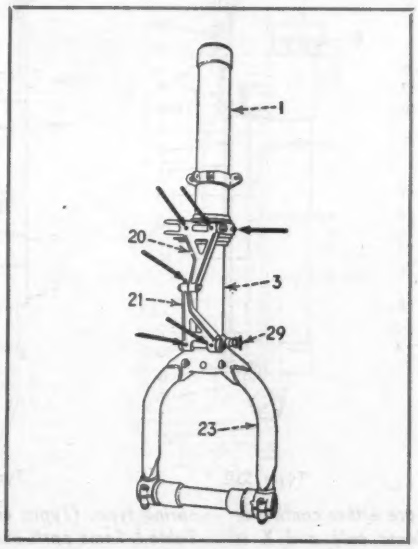


Fig. 2. Nose Aerol, with heavy arrows indicating lubrication points. Action of nose unit is same as that of main wheel type. However, there is addition of cams (9) and (30), which keeps wheel straight when landing or retracting gear. For quick turning on ground or in hangar, locking pin (29) is attached to hinge of lower torque arm (21).

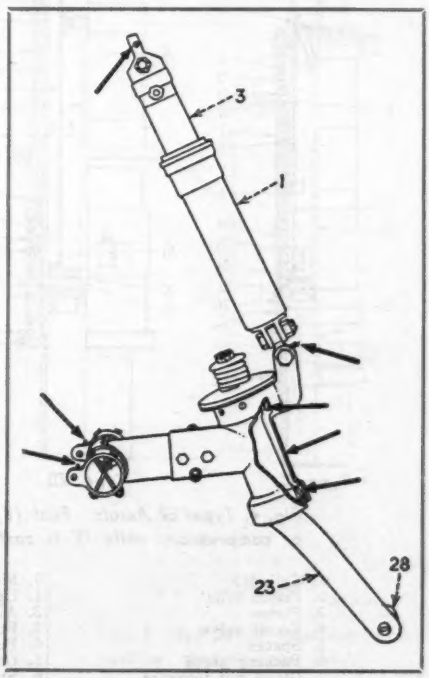


Fig. 3. Tail wheel Aerol lubrication points are shown by heavy arrows. Spring and friction disks are for reducing shimmy.

tacts stop (25), further extension depends entirely upon gravity. To facilitate this a relief valve is placed in plate (15). Air pressure only comes into action during the end of the compression stroke, when taxiing and while in static position.

Type X functions much like type IV. Here, however, a helical steel spring (16) takes the place of compressed air in the cylinder.

To remove an Aerol, deflate tire and remove tire, wheel, and brake. Make sure that all air has been removed from Aerol by depressing valve core until all hissing has ceased. *Serious accidents may occur if this precaution is not observed.*

To install, first fill Aerol (in vertical position with piston fully compressed) using Aerol mineral oil, "Univis 40," or "Intavo Servo Fluid," as specified by the makers and with conformation to Army or Navy specifications.

To expel air, move piston through full stroke two or three times, then recheck oil level, refilling to level of filler plug hole if required. Then replace valve assembly.

Attach Aerol to airplane and install tire, wheel, and brakes. Inflate tire. Then to inflate Aerol, place plane in a hangar, where wind or propeller slipstream will not affect it. Full normal load should be applied while inflating. For this purpose only air should be used because bottled gases are subject to danger of explosion from sudden heat

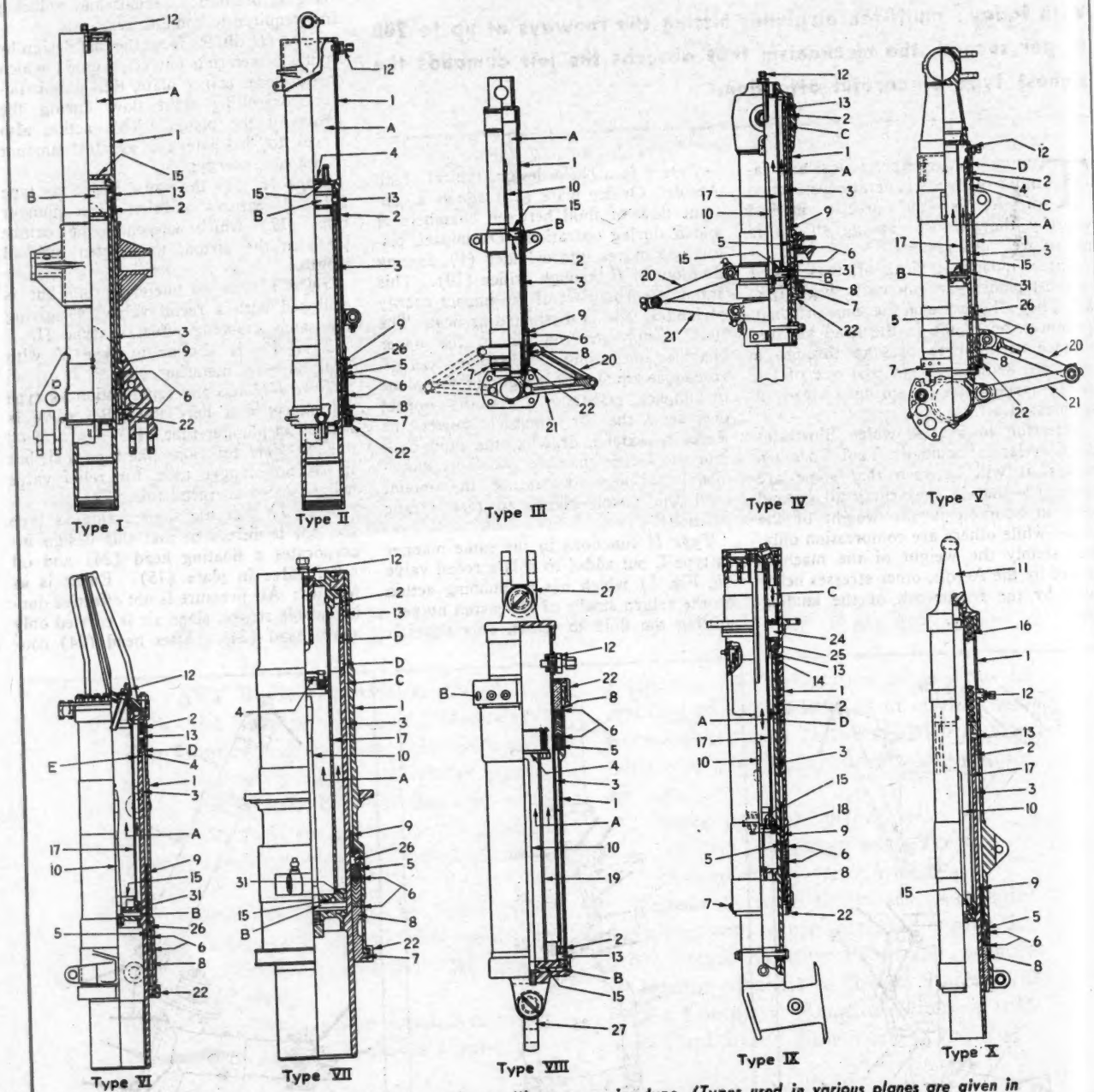


Fig. 4. Types of Aerols. First (8) are either cantilever or compression, while IX is cantilever only and X is spring type. (Types used in various planes are given in Table I. Same parts numbers are used in all illustrations.)

1. Cylinder
2. Piston head
3. Piston
4. Recoil valve
5. Spacer
6. Packing gland
7. Gland nut lockwire
8. Bearing
9. Follower
10. Metering pin
11. Upper terminal
12. Air valve body
13. Piston head setscrew
14. Piston head locknut
15. Orifice plate
16. Steel spring
17. Plunger tube
18. Oil relief tube
19. Recoil tube
20. Upper torque arm
21. Lower torque arm
22. Gland nut
23. Fork
24. Floating head
25. Floating head stop
26. Follower nut
27. Universal
28. Axle
29. Locking pin
30. Upper locating cam, nose Aerol
31. Plunger head ring
A. Upper chamber
B. Lower chamber
C. Outer annular chamber
D. Piston large hole
E. Piston small hole

of compression when absorbing impact energy. In case of extreme emergency, high pressure carbon dioxide may be used, but its continued employment is not recommended. A pump should be used which is capable of delivering air at 600-700 psi. Piston should be inflated until red line (painted around tube) is flush with lower edge of gland nut with full load applied. To avoid over inflation, ship should be rocked or rolled slightly to overcome gland friction.

If Aerol is being inflated for first time after overhaul, inflate until extended about ¼ in. longer than usual, in order to allow for absorption of air by fluid. Final variation of ¼ in. either way should not be considered important.

Check air valve and valve body gasket for leakage. Standard tire valves are not satisfactory, a special oil-resistant rubber unit being required.

Inspection and Maintenance

As taxiing shocks are absorbed by the air in the cylinder, daily checks should be made for leakage. Examine valve for leaks (Fig. 6) by applying a small amount of oil on top. If leakage is present, depress valve and allow to snap back on seat. Inspect filler plug for leakage in same manner. If leakage is not stopped, leaky parts should be replaced *after Aerol has been deflated.* No parts subject to air or oil pressure should be used if they show scratches or signs of previous use.

It is essential that all packing be absolutely clean, since dirt will hold the packing away from the surfaces and cause continuous leakage (Fig. 7). Pressure-equalizing tubes between Aerols should be carefully inspected because any defect or leakage will result in deflation of both units. Fluid level should be checked if striking of top or bottom is reported during ordinary usage.

When deflating, depress air valve until all fizzing has ceased and remove valve assembly and filler plug. Remove lockwire or lock screws on gland nut. Loosen gland nut about one turn, work piston up and down several strokes, and tighten gland snugly, but not too tight. Replace lockwire and screws and fully compress Aerol. Check fluid level, which should be up to filler plug hole. Replace filler plug and inflate until at correct length under load.

Every 25 hr. entire outside of mechanism should be cleaned and inspected for signs of cracks, chrome plating must be inspected for corrosion or scoring, cotter pins and safety wiring must be checked for chafe or looseness, and any defective

(*Turn to page* 247)

Table I—Types of Aerols Used in Various Planes

Type	*Used on*
I	XP-59 (jet "Aircomet")
II	P-59
III	Lockheed 49, P-47B, C-46
IV	AT-9, PBY-5A, P-47B, B-26B
V	A-20, XA-26
VI	B-26, C-46
VII	P-39
VIII	SBN-1
IX	Douglas planes, F4U-1
X	PT-13, N3N-3

(Since design changes are constantly taking place, this listing is always subject to revision.)

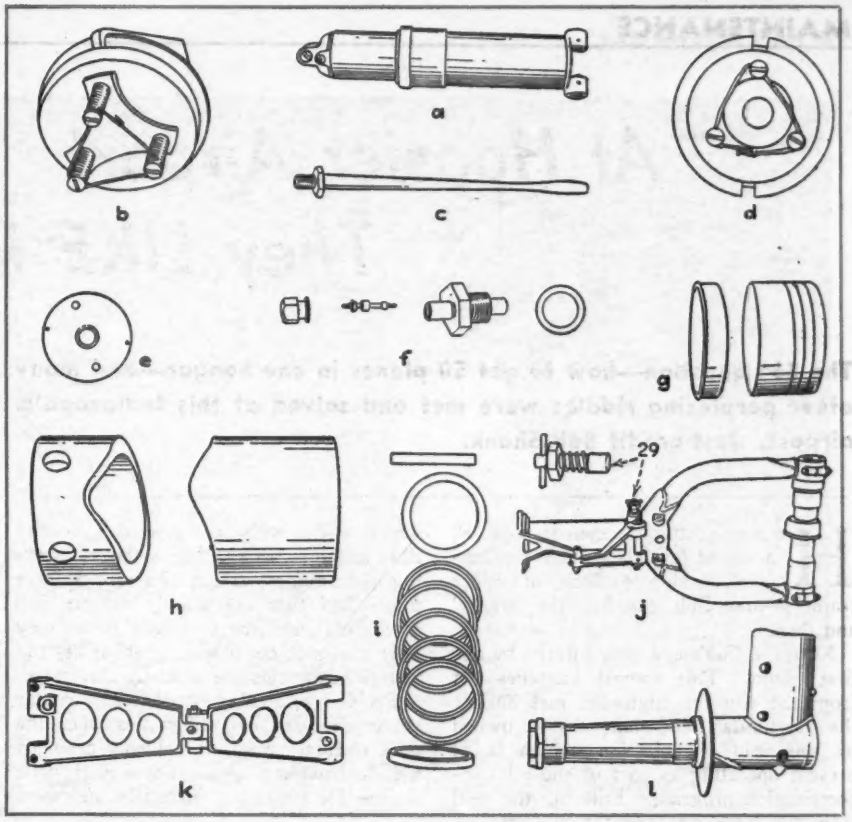


Fig. 5. Essential parts: a is piston (3) and cylinder (1), b recoil valve (4), c metering pin (12) (used on types II, V, VI, VII, & VIII), d oil relief valve (18) (used on type IX), e orifice plate (15), f filler inlet and air pressure valve (12), g bronze bearings (2) and (8) for cylinder alignment, h locating cams for nose Aerol, i packing gland (6), j locking pins (29) on lower torque arm, k upper and lower torque arms (20) and (21), and l axle (28) attached to lower cylinder.

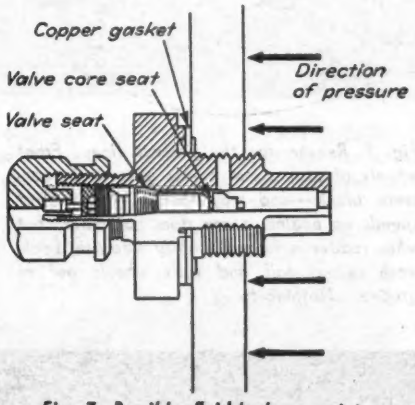


Fig. 7. Possible fluid-leakage points.

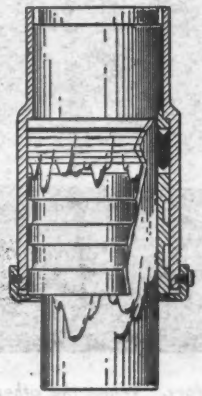


Fig. 6. Possible air-leakage points.

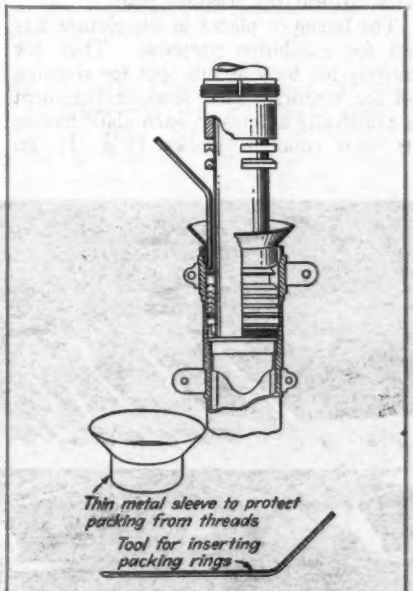


Fig. 8. Method of applying packing, showing tools used.

At Hoosier Airport They LIKE Problems

The $64 question—how to get 50 planes in one hangar—and many other perplexing riddles were met and solved at this Indianapolis airport. Just credit Bob Shank.

HOOSIER AIRPORT consists of 80 acres of level land near Indianapolis, a whole flock of Piper trainers—and Bob Shank, "the brains" and owner.

Note the *Cub's*-eye view offered by our first photo. This airport stretches out from the Chicago highway, just outside the city limits. The planes are all owned by the field organization, which is at present operating as part of the pilot indoctrination program. Entering the field from the highway (seen at the left) by means of a lane dimly visible in the photograph, one finds a parking lot between the two large hangars. Next to the hangar and beyond it is the office building, and adjacent are plane storage sheds and shops.

The buildings are constructed around three sides of a square so that, in windy weather, planes will be protected prior to being pushed into the hangar, an operation which may be performing through side doors when conditions render opening of front doors inadvisable. A neat trick to beat the weather man.

The lineup of planes in the picture was not for exhibition purposes. They are entirely too busy at this spot for showing off for visitors. That straight alignment is practically automatic, each plane having its own concrete blocks (Fig. 1) on which the wheels are placed. Result: Easy and accurate spacing, without jockeying, shouting, or waving of arms. Student pilots find that the usually difficult job of taxiing into line is simple when they have the concrete blocks to shoot at, and tattered wing tips are virtually eliminated.

Problem of airplane storage and hangar space presented real difficulties when the pilot training program suddenly crowded the field with planes. There was little chance for obtaining materials and even less likelihood of finding men to build the hangars. So the structures on hand had to be "stretched".

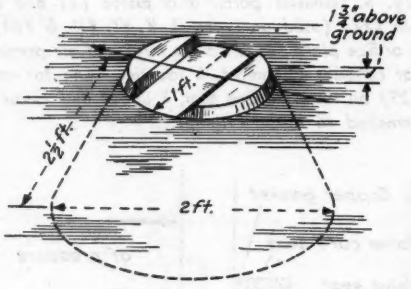


Fig. 1. Reason for the perfect line. Front wheels of planes run across grooves in concrete blocks—and stay there. When pilot speeds up engine, plane does not move; but when rudder is turned slightly sidewise, backwash swings tail and rolls wheels out of groove. Nothing to it!

How this was done is shown here in two photos. An assistant raises the tail of the plane until it overbalances and tilts forward. He then prevents too much tipping by holding the tail by means of a short rope looped round the tail wheel. The rubber-tired dolly is then rolled in front of the tilted plane and the swiveling L-shaped pin (shown closeup in sketch) is inserted into hollow propeller shaft. Weight of the plane is taken by the dolly, and the swiveling pin permits it to be wheeled into any position. The planes are stacked up as shown in our hangar view, with a padded V-blocks under the hubs of the horizontally turned propellers.

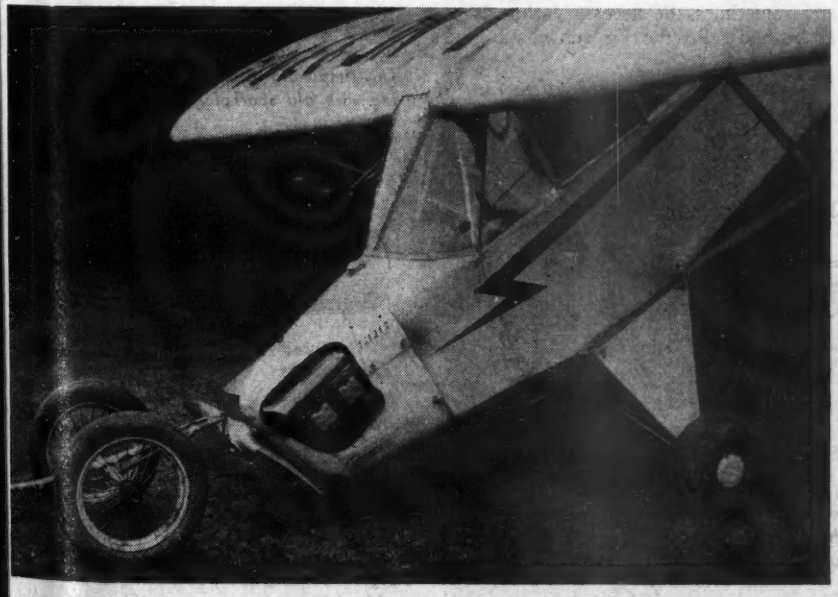
Lost space is reduced to about 6 in. between one planes' cabin roof and the next one's bottom. Sidewise the wings overlap as closely as the struts permit. This system—simple when you see it—enables 50 primary trainers to be kept in a hangar 86 ft. wide and 128 ft. deep, using only 220 sq.ft. per plane bench and tool space being included in this figure.

Servicing and maintenance are always major problems in flight schools, where a g'ven number of planes must take off within a certain period. Tools and testing equipment are almost impossible to obtain, due to the needs of an evergrowing AAF and of the manufacturers who supply them. Therefore, when equipment could not be done without, it had to be made.

Here are some of the more notable results of the campaign which licked priorities:

Thirty planes where 10 stood before. When the other 20 come in, there will still be plenty of room. In this 86 x 128 hangar there's no housing problem at all.

Hoosier Airport, with a lineup of planes that would look good on any AAF field. Bob Shank (insert) pilot license No. 1448, Early Bird, and World War I flyer, with over 6,000 logged hours, started this airport in 1928. It is one of the best examples of what can be accomplished as a result of the combination of private initiative and the facilities of an excellent flying field.



Rubber-tired dolly to lead a Cub around by the nose. With this device, one man can haul a plane anywhere, in or out of the hangar.

An hydraulic press was badly needed for work too heavy for the regular arbor press. A junk yard supplied several lengths of channel steel, which were welded together (as shown in Fig. 2), then fastened into two nondescript base castings obtained from the same yard. An ordinary auto hydraulic jack supplied the necessary force, and the whole job only cost about as much as the freight on a "store" machine. Power is ample for the small engines used, and adjustments for height are made by raising or lowering the sliding cross member. This part has the end-adjusting holes drilled off center, so that close adjustments may be made merely by turning the beam so that the opposite side is uppermost.

For testing Eisemann magnetos used with the Franklin engine, a fixture was made for use on the slide-rest of a South Bend lathe. As shown in Fig. 3, the vertical plate carries four spark gaps, set into a glass tube. Lower side is grounded while the upper is connected to the four secondary wires of the

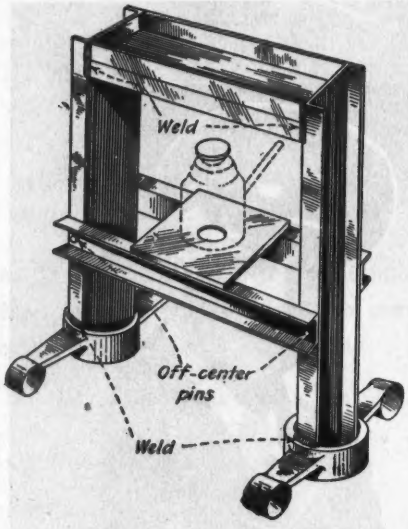


Fig. 2. Today this is an indispensable hydraulic jack—but it was just so much junk a few months ago. Offset holes in cross member allow close adjustment, and power is provided by hydraulic jack set in table.

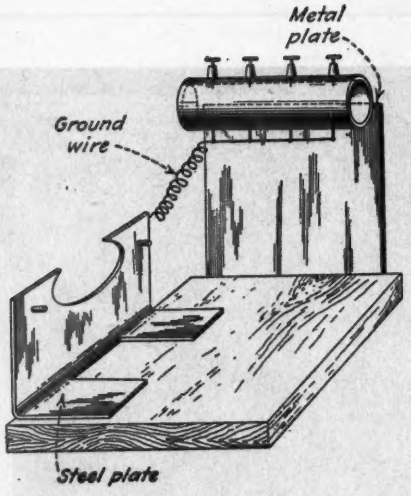


Fig. 3. Magneto tester fits onto lathe, which provides motive power and saves hunting for a scarce motor. Spark gaps are in glass tube.

magneto. The magneto itself is attached to the steel plate (left in sketch) being located by the two studs welded into the plate. A magneto coupling is attached to the lathe chuck, and the wood base of the test stand is clamped down onto the saddle of the slide-rest.

This makes a simple, yet complete, test stand, without the necessity for using another hard-to-find electric motor.

For run-in tests and adjustments, the rear section of a cracked-up plane is used as an engine stand. As can be seen in Fig. 4, two front wheels have been attached by welded arms, coming far enough forward to enable the crossbar between the axles to serve as a guard when the propeller is turning.

The rubber tires of the front wheels form excellent shock absorbers, insulating from the floor without the necessity for an expensive and clumsy foundation for a stationary test stand. The method of attaching the engine is noteworthy.

Across the front of the 1-in. angle frame at the "business end" of the stand, is welded a joggled strip of heavy steel. The cross angle of the engine mount is hooked over this strip and holds the engine securely, even when revved up. To guard against possibility of side motion from vibration, a small bolt is inserted into the engine mount near each lower corner of the angle frame. The stand has a complete engine instrument board and a fuel tank with capacity for a fairly long run. The rear wheel can be immobilized during tests. and an anchor cable is also attached to the frame back for the same purpose.

Sparkplug-hole threads in cylinder heads are frequently damaged or need replacement after wear. Setting up for drilling and tapping, by ordinary drill press methods, is slow and exacting work, and sometimes the necessary time is not to be had. So the jig shown (Fig. 5) was devised and this hitherto long and complicated job became easy.

The large steel plate is drilled to clear the valve springs, also for fastening down to the studs used for holding the valve rockers. The smaller portion of the plate is bent downward until it is at right angles to the center line of the sparkplug hole. The hardened bushing is threaded in place for guiding a ½-in. pipe tap drill in a portable electric drill, which cuts out the old threads and leaves a hole the right size for retapping for the bushing.

Another bushing, which fits the shank of the tap, is set in place and the tap is used to thread the hole. A collar is attached to the upper portion of the threads on the tap with which the bushing is threaded and serves to turn the bushing into the hole until the collar seats on the cylinder casting, at which time the bronze bushing is firmly held by the tapered pipe threads. Another tap, also with a shouldered portion, is then used to clean out the sparkplug hole threads to complete the operation. The bushing is

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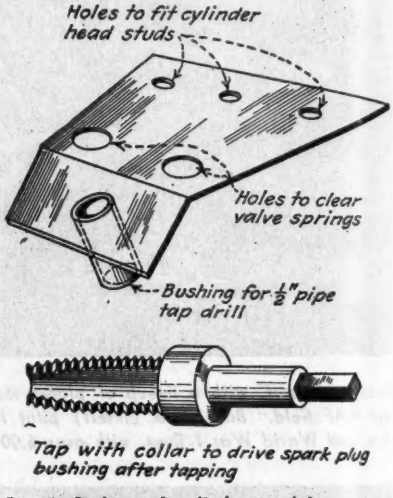

Holes to fit cylinder head studs
Holes to clear valve springs
Bushing for ½" pipe tap drill
Tap with collar to drive spark plug bushing after tapping

Fig. 5. Bushing of cylinders reclaims a number which would otherwise be thrown away. This simple jig assures alignment of new bushing with old sparkplug hole.

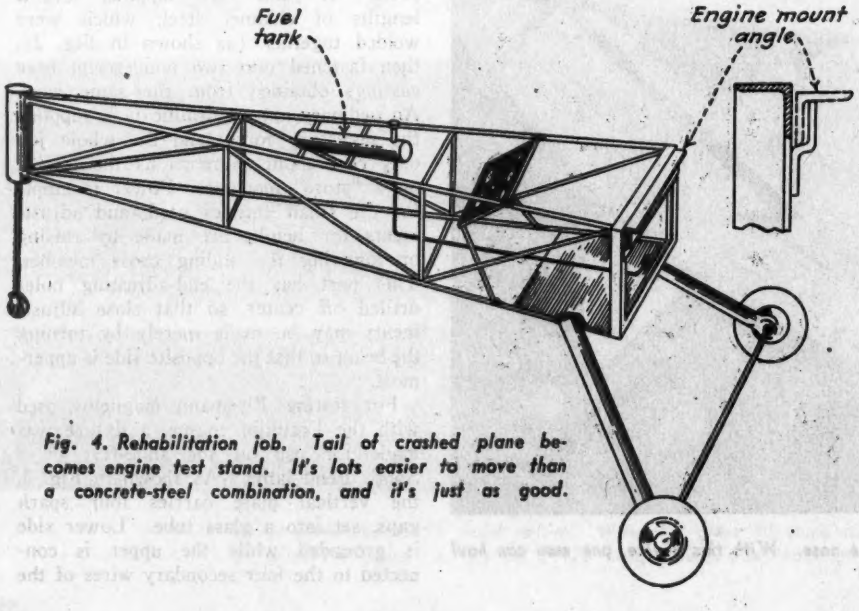


Fig. 4. Rehabilitation job. Tail of crashed plane becomes engine test stand. It's lots easier to move than a concrete-steel combination, and it's just as good.

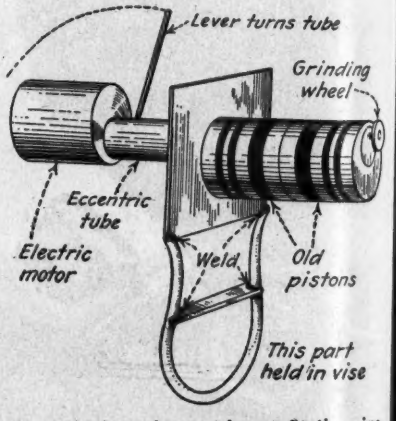


Fig. 6. Making the punishment fit the crime, old pistons are now part of machine which removes shoulders which they formerly wore in cylinders.

AAF Devises All-Purpose Loosening Tool

"HANDLE, SOCKET-WRENCH, IMPACT-DRIVEN - SCREW - AND - NUT - LOOSENER," is the imposing name given to a manually operated tool to be included in AAF kits and sets, following its development by the Miscellaneous Branch Equipment laboratory, Material Command, Wright Field, Dayton, Ohio, for the purpose of removing screws, bolts, and nuts seized because of high torque installation or corrosion.

The tool also enables the mechanic to remove damaged or burred screws, because its action indents the screw sufficiently for removal.

Essentially the new tool operates similarly to the spiral-ratchet-action screw driver known as the Yankee, except that the handle is shorter, made of metal, and the rotation is accomplished by a hammer or mallet blow on the handle, instead of by pushing it down by hand to obtain action on the ratchet. It is equipped with a $\frac{3}{8}$-in. male square drive to which can be fitted screw driver bits and sockets now alloted to AAF mechanics.

To remove a stubborn screw or bolt, the mechanic pounds the handle of the tool, then the drive rotates with sufficient force to loosen the seized fastening.

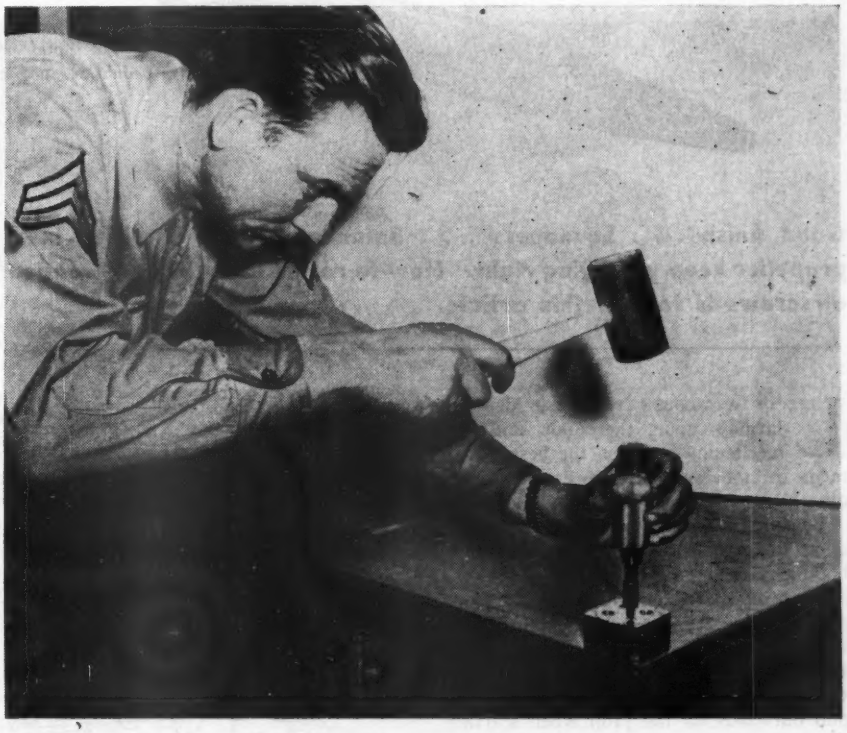
Action of the tool eliminates camming, the cause of damaged screwheads, since the hammer blow forces the bit firmly in the recess of the screw. Importance of the device may be appreciated—especially if the problem of a mechanic who has to remove the de-icer boot from one wing of a B-17 is considered. He has to remove approximately 1,000 screws, at least 1 percent of which will be seized by corrosion. If he damages a screw head he is confronted with the additional work of drilling, extracting, and tapping for an oversized replacement screw.

The loosening tool is regarded as a valuable addition to the mechanic's kit—as a time, labor, and material saver and for preventing damage to screw heads and to airplane skin.

In a recent service test, a Wright Field mechanic, using the new loosener, removed more than 50 No. 10/32 screws from the wing tank access doors of a B-26. These screws were impossible to start with the standard type screwdriver.

To describe the tool more completely, it consists of a metal barrel, knurled to fit the hand, and a shaft operating within the barrel by means of a helical spline which causes the shaft to rotate 45 deg. counter-clockwise for $\frac{1}{2}$ in. axial stroke. The shaft is spring loaded and normally remains extended. It terminates in a $\frac{3}{8}$-in.-sq. drive to fit either of two holders accommodating standard bits and bolt sockets.

Hammer or mallet blows on the head of the barrel create a turning force on the shaft, which loosens the screw while preventing damage to its head.



AAF mechanic demonstrates use of new screw loosener.

Striking tool with hammer, mechanic loosens screws in wing.

LONG LIFE For Your Wooden Props

Fig. 1. Wood propeller, showing laminations and contrasting grain.

Good finish . . . Soundness . . . Balance. These qualities in a propeller keep you flying right. How to retain them in your wooden airscrews is told in this article.

LIFE OF A WOODEN PROPELLER depends largely upon the pilot and the mechanic—for even the best equipment cannot long survive careless handling.

Bearing this fact in mind, let us see what the pilot can do to help, or harm, his propeller.

First of all, he should remember that the blades are designed with great strength so far as taking working stresses are concerned, but that they are otherwise rather fragile. It is not advisable to pull outwards on the prop when starting the engine, as cracks are easily started that way, nor should the blades be used as convenient handles for pushing the plane around. This may sound elementary, but it happens every day.

In addition, the man who revs up his engine when the blade tips are only a short distance from gravelly ground is going to find trouble without even looking for it. Grit and sharp fragments will remove the varnish, scar the wood, and scratch the tipping so deeply that it will eventually crack. Moreover, to leave a wet propeller with one blade down, after stopping your engine, will do no good fast. Blades should be kept horizontal when wet and should be turned half a revolution every 12 hr. If you do much wet weather flying, get a cover and use it—but remember to take it off before starting the engine.

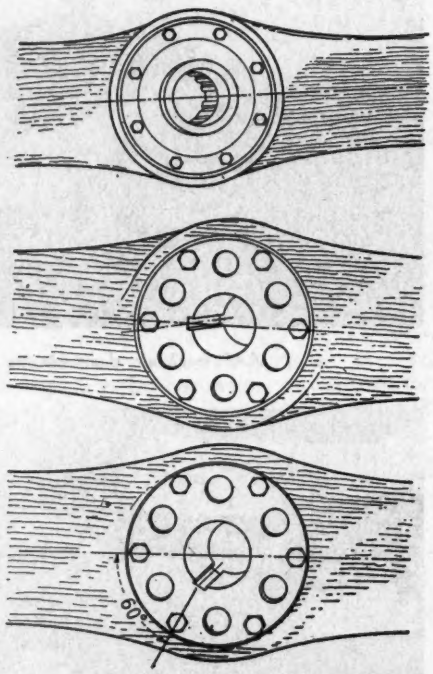


Fig. 2. Three types of hub used. Top: Splined hub where c/1 of No. 1 blade is in line with wide spline. Center: Type with tapered shaft with c/1 of No. 1 blade on c/1 of keyway. Bottom: Continental No. 0 taper shaft with c/1 keyway 60 deg. clockwise from blade c/1.

Service Inspection

Daily inspection should be made before warming up the engine. Check all hub bolts and nuts for tightness, using an open-end wrench. If any looseness should be detected, tightening should be done with a torque wrench, using 200 in.-lb. for smaller propellers and 250 for larger ones. The shaft nut should also be checked for play.

Check for loose screws. These may be detected by the crack which will develop around the solder covering the head. If more than three are loose in one section of propeller, they should be replaced immediately (see instructions for tipping for this operation). Clean surface of propeller and inspect varnish carefully for cracks or scratches. Examine the fabric covering. As torn fabric or scratched varnish will admit moisture, which may cause considerable damage later, these defects should be remedied before flight.

The 25-hr. inspection includes the daily check and in addition the following steps:

(a) Remove propeller from engine and check for balance and track (Figs. 3, 4, and 5). Blades should track within $\frac{1}{16}$ in. Clean propeller with soap and water or a cleansing agent which will not affect the finish.

(b) Examine for defects which would cause failure (Fig. 6).

(c) Sand to a feather edge all places where finish is worn or scratched, then apply two coats of varnish. Allow to dry for 12 hr., then polish entire surface of propeller with two coats of rubbing wax.

(c) Inspect tipping for looseness and for signs of slipping, separation, or corrosion. Also check screws for looseness, and examine surrounding metal for cracks. Straight cracks at right angles to edge of blade may not be serious, but those running into screw holes definitely are. Do not attempt to solder these cracks; instead, remove propeller for retipping.

Every 100 hr. the following inspection should be made:

(a) Remove propeller from engine, take out hub, and inspect bore for cracks or separation of laminations.

(b) If Magnaflux is available, inspect hub for cracks.

(c) Inspect tipping (as in 25-hr. inspection).

(d) Examine wood portion for cracks. Checks in varnish should be scraped to determine if they extend into wood. If so, propeller should be sent to shop for repair or should be condemned if cracks are too deep.

(e) If finish is in good condition, touch up scratches and polish with two coats of wax. If many places require finishing, prop should be sent to repair shop. Small areas of fabric may be repaired according to instructions later in this article. Entire fabric covering may be removed from

Fig. 3. Left: To balance propeller, first remove hub and cones, clean hub bore, replace hub, and tighten with torque wrench using 200–250 in./lb., according to size. Center: Hang propeller over knife edges. Right: Insert oiled hub spindle. Then lower onto brass end of knife edge and roll gently to center, taking care that no dirt is present either on spindle or knife edges.

Fig. 4. Left: First test for horizontal balance by attaching small pieces of clay or other material which will adhere to metal. Propeller should stand still or rotate slowly. Center: Then test for vertical balance. If prop moves, note direction of rotation. Right: Then add weight until satisfactory balance is obtained allowing propeller plenty of time to change position.

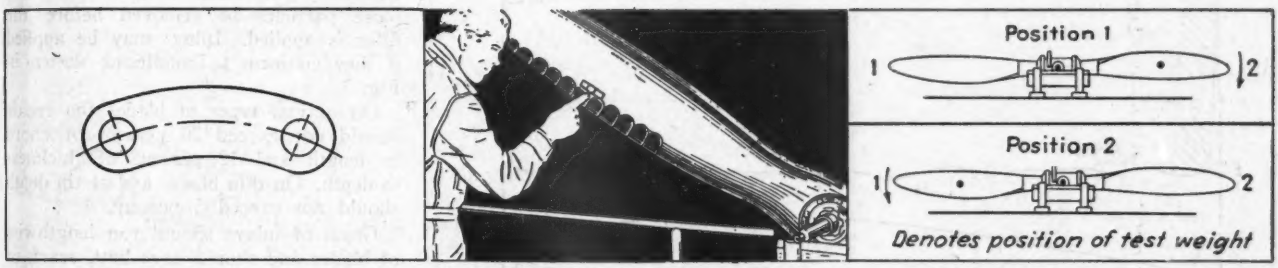


Fig. 5. Left: Sheet steel balance weight is made equal to test weights. Center: Check for final balance is penny attached with adhesive tape. Position is 1 in. from center for each 10-lb. weight of prop. Right: Here diagram shows direction propeller should turn when weighted after testing. Dynamic balancing is considered in final portion of this article.

both blades if surface is given *four* coats of varnish.

(f) Re-install hub, balance, and check for track. This should also be done whenever there is complaint of roughness in operation, since propeller may have become warped through dampness or overstress. Small breaks in finish may be repaired by refinishing, but where total area is more than 4 sq.in. the propeller will become unbalanced and should be completely refinished.

Loose screws are to be replaced when solder shows evidence of cracking. Procedure is as follows: Apply hot soldering iron to solder and remove with stiff brush while still liquid. Remove screws and replace with next larger size. When holes are too large for ⅜-in. screws, plug holes and use No. 4 ½-in. screws. No. 5 ½-in. wood screws are largest size permissible.

Overhaul

When the outside lamination is found to have a loose glued joint, repair may be made by planing off the lamination and gluing on a new one of yellow birch. Other laminations should not be repaired.

Small cracks parallel to grain in other laminations may be repaired by working glue thoroughly into crack, drying, and finally finishing with varnish.

Crushed laminations, damaged by excessive bolt pressure, are repaired by planing smooth the less-damaged side and replacing the other lamination, which is worked to bring hub thickness to original dimension. Procedure is as follows: Plane off old lamination and prepare new one. Make wooden blocks to fit over profile of blade, 4 in. apart.

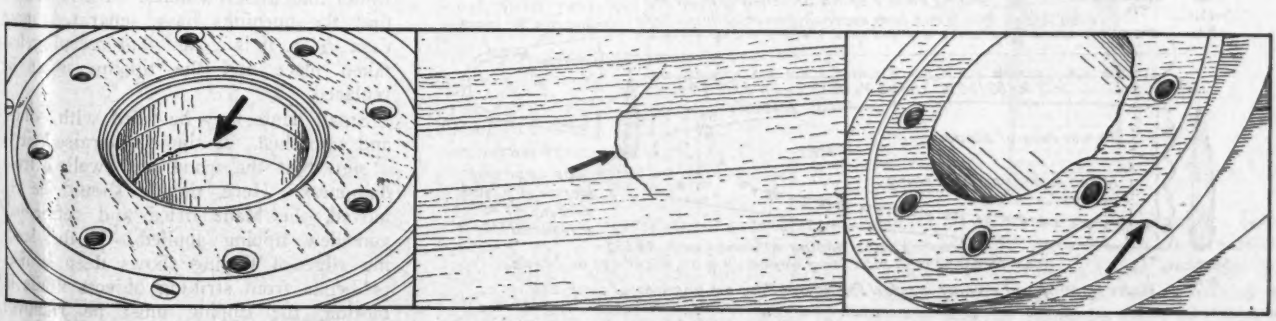


Fig. 6. Reasons for rejection are: Left, separation of laminations; center, crack across grain; and right, elongated bolt holes, cracks in hub, or weather checks.

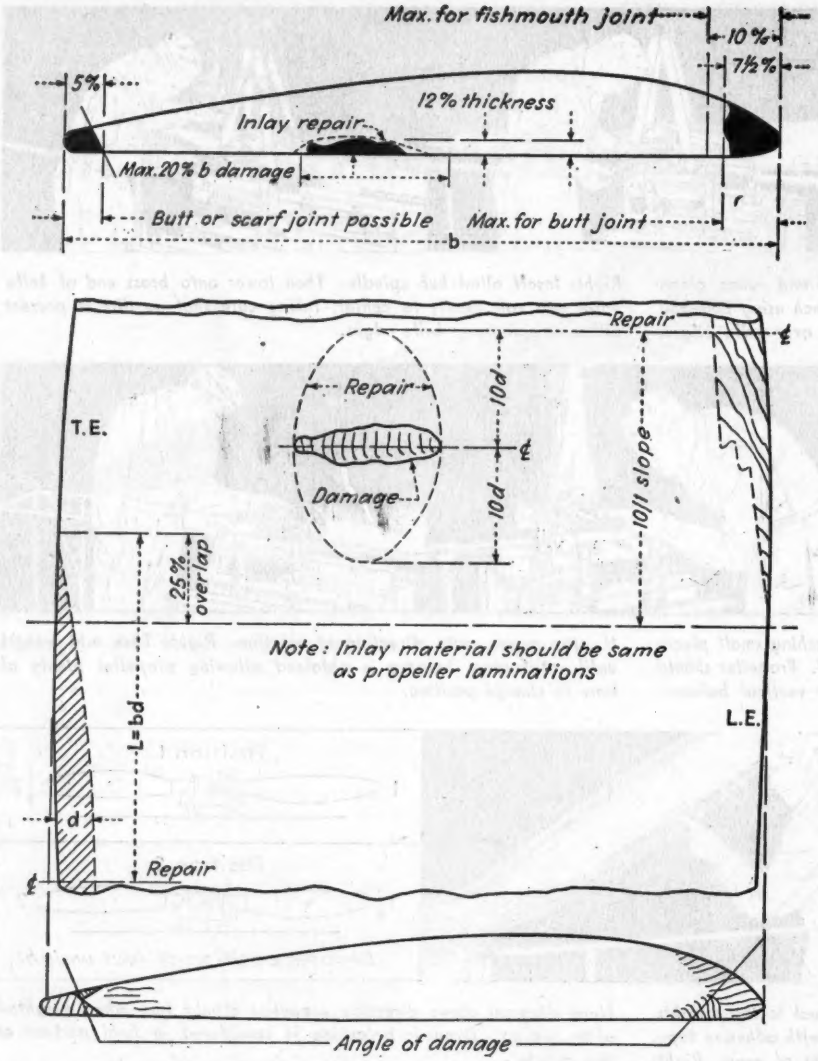


Fig. 7. Inlay should follow limits given above, and material should be same as that of laminations.

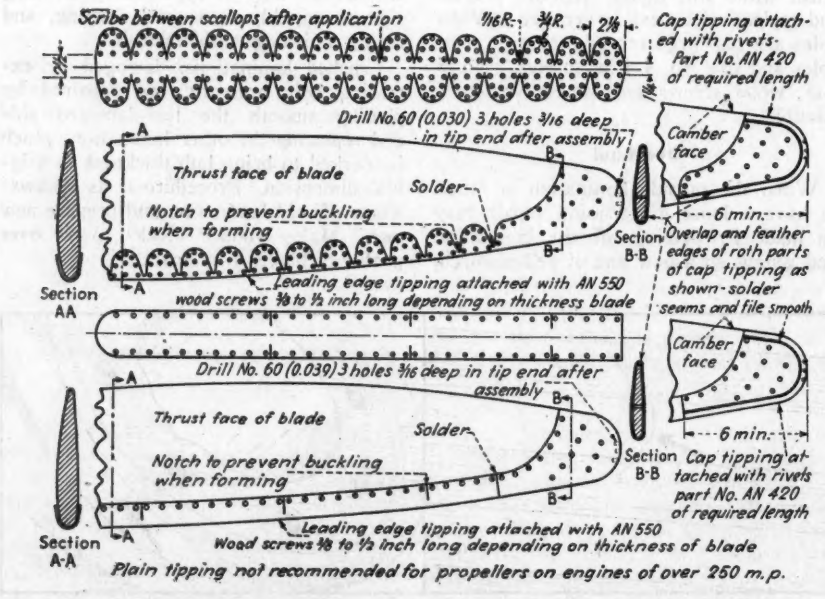

Scribe between scallops after application
1/16R
3/4R
2⅛
Cap tipping attached with rivets Part No. AN 420 of required length
Drill No. 60 (0.030) 3 holes 3/16 deep in tip end after assembly
Camber face
Thrust face of blade
Solder
Notch to prevent buckling when forming
6 min.
Section B-B
Overlap and feather edges of both parts of cap tipping as shown - solder seams and file smooth
Section AA
Leading edge tipping attached with AN 550 wood screws ⅜ to ½ inch long depending on thickness blade
Drill No. 60 (0.039) 3 holes 3/16 deep in tip end after assembly
Camber face
Thrust face of blade
Solder
Notch to prevent buckling when forming
6 min.
Section B-B
Cap tipping attached with rivets part No. AN 420 of required length
Section A-A
Leading edge tipping attached with AN 550
Wood screws ⅜ to ½ inch long depending on thickness of blade
Plain tipping not recommended for propellers on engines of over 250 m.p.

Fig. 8. Two methods of cutting tipping for blades and system of application.

After blocks are made and tested for fit on surface, glue surfaces of both blade and new lamination, using cold-setting resin glue conforming to Army specification AN-G-8. Clamp and leave under pressure for time recommended by manufacturer of glue.

Allow glue to season for three or four days, then taper ends of new lamination so that planer will only cut surface near hub. If this is not done, it will be impossible to prevent propeller from tipping when in planer.

Carve down new lamination to match curve of blade. If more than 30 percent of radius from center, templates should be used. These should be measured from blade before old lamination is removed, unless an identical propeller is available from which they may be copied.

Bore new lamination and chamfer edges of holes. Sand with No. 2/0 sandpaper, and varnish with three coats.

Dents and scars which do not impair safety may be filled with a mixture of glue and fine, clean sawdust, provided the cavity is of such shape that it will hold the repair securely. The repair is then sanded and finished in the same manner as the rest of the blade. It is extremely important that all dirt and loose particles be removed before the filler is applied. Inlays may be applied if they conform to conditions shown in Fig. 7.

On normal types of blades the repair should not exceed 20 percent of chord in length and 12 percent of thickness in depth. On thin blades and at tip depth should not exceed 5 percent.

Grain of inlays should run lengthwise of blades and should have butt, scarf, or fishmouth joint, the last being the most preferable and the butt least. Number of inlays should not exceed one large, two medium, or four small per blade and should not overlap by more than 25 percent of length of inlay, when on opposite edges.

Narrow splinters broken from trailing edge may be sandpapered smooth and refinished, reducing both blades by the same amount to keep balance. Least possible amount of material should be removed, consistent with smooth fairing of edges.

Constant bending of the blade under working stresses would normally cause cracking of tipping. To obviate this, sawcuts are made at several points, so that the cracks may take place there rather than at screw holes. If it is noticed that the openings have separated more than $\frac{1}{64}$ in. it is a sign that creeping has taken place and the tipping must be replaced.

Small dents may be filled with solder and smoothed. If tipping is raised, it is a sign that the wood has swelled from dampness. Here, tipping should be removed, the blade dried and refinished, and new tipping applied. If the leading edge of tipping shows deep bruises or bends from striking objects while in motion, the tipping must be removed for examination of the wood beneath.

To apply new tipping, flatten out old

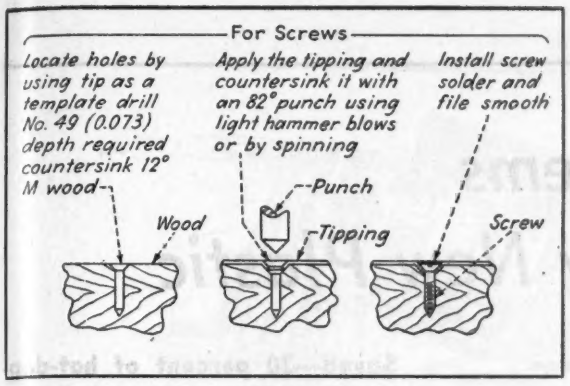

For Screws
Locate holes by using tip as a template drill No. 49 (0.073) depth required countersink 12° M wood
Apply the tipping and countersink it with an 82° punch using light hammer blows or by spinning
Install screw solder and file smooth
Wood
Punch
Tipping
Screw

Fig. 9. Screw fastening for tipping and use of punch for dimpling metal.

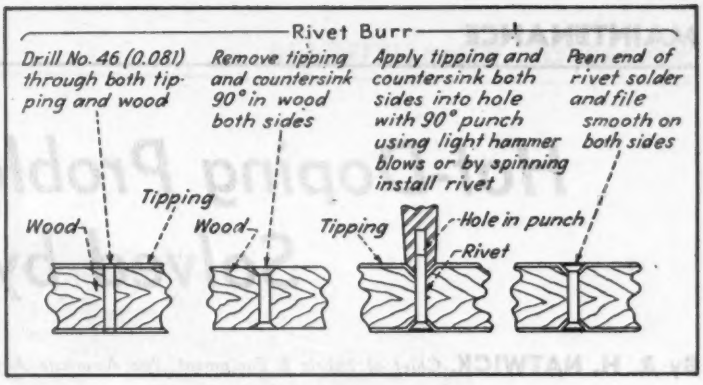

Rivet Burr
Drill No. 46 (0.081) through both tipping and wood
Remove tipping and countersink 90° in wood both sides
Apply tipping and countersink both sides into hole with 90° punch using light hammer blows or by spinning install rivet
Peen end of rivet solder and file smooth on both sides
Tipping
Wood
Wood
Tipping
Hole in punch
Rivet

Fig. 10. Riveting technique. Hollow punch is used for dimpling round rivet.

Fig. 11. Block with tapered bar used in heading tip rivets.

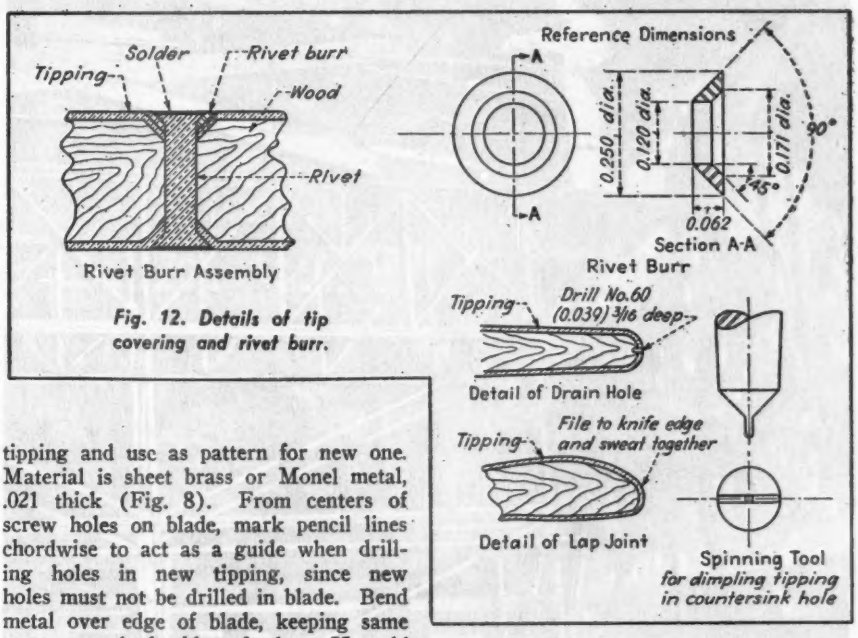


Fig. 12. Details of tip covering and rivet burr.

tipping and use as pattern for new one. Material is sheet brass or Monel metal, .021 thick (Fig. 8). From centers of screw holes on blade, mark pencil lines chordwise to act as a guide when drilling holes in new tipping, since new holes must not be drilled in blade. Bend metal over edge of blade, keeping same amount on both sides of edge. Use old tipping marks as a guide. If slight waves appear, disregard them, for they will be eliminated later. Bind metal to blade with strong rubber tape, ½-in. wide and ¼-in. thick in 4-ft. lengths, being careful not to cover pencil marks.

Tap metal down onto leading edge with a rubber mallet, then flatten down onto blade using a weighted backing block fitted with a leather pad to bear against the back of the tipping. Check to see that metal has not moved, then mark out holes with center punch, using pencil marks as a guide. Holes will be about ¼ in. from edge of metal. Remove metal, drill, and file off burrs on inside. Clean out old holes in blade with a drill.

Cut or saw slots in metal, obtaining location from old part. Fasten in place with rubber tape. Dimple holes into blade with center punch (Fig. 9) so that screws or rivets will not be more than $\frac{1}{32}$ in. below surface. Insert screws one size larger than previously, or if rivets are used, place rivets with countersunk head on flat or back of propeller blade (Fig. 10). Using a bar pointed to fit rivet heads, head up all rivets (Fig. 11).

Cut a hardwood block, shape of tip, for

(Turn to page 251)

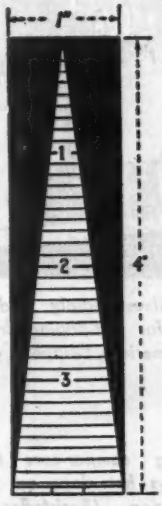


Fig. 13. Propeller balancing vibrometer. Side motion of card gives illusion of a central inverted "V" of varying height, which can be measured on cross lines, thus providing a simple means of comparing effect of different balance weights.

Hot-Doping Problems Solved by New Plastic

By **R. H. NATWICK,** *Chief of Fabric & Equipment, Pan American Airways.*

Saved—30 percent of hot-doping time. This is the record rung up by PAA with the use of a special flexible hose lining.

ADOPTION by Pan American Airways of the hot-doping process for finishing fabric surfaces of its *Clippers* brings to the foreground a synthetic plastic conduit for hot solvents. The problem was to find a wear-resistant flexible conduit impervious to chemical action of hot colloidal dope, and it was solved with the use of a vinyl resin hose known as Resistoflex compar. This points to other adaptations in fields where similar exacting conditions must be met.

After Pearl Harbor, when it became necessary to camouflage *Clippers* rather than give them the usual aluminized dope finish, practical difficulties developed which proved extremely expensive, both from the standpoint of material and labor, and also loss of time when out of service. It was found that camouflage finishes cause rapid deterioration of doped surfaces, particularly on aircraft that spend a large part of their operational time in the tropics, where humidity and temperature conditions hasten such action.

Frequent replacements of fabric became necessary at a time when wartime schedules necessitated keeping the *Clippers* in operation over 350,000 mi. per year. At best, doping was a slow process, requiring 84 hr. per 1,000 sq.ft. The

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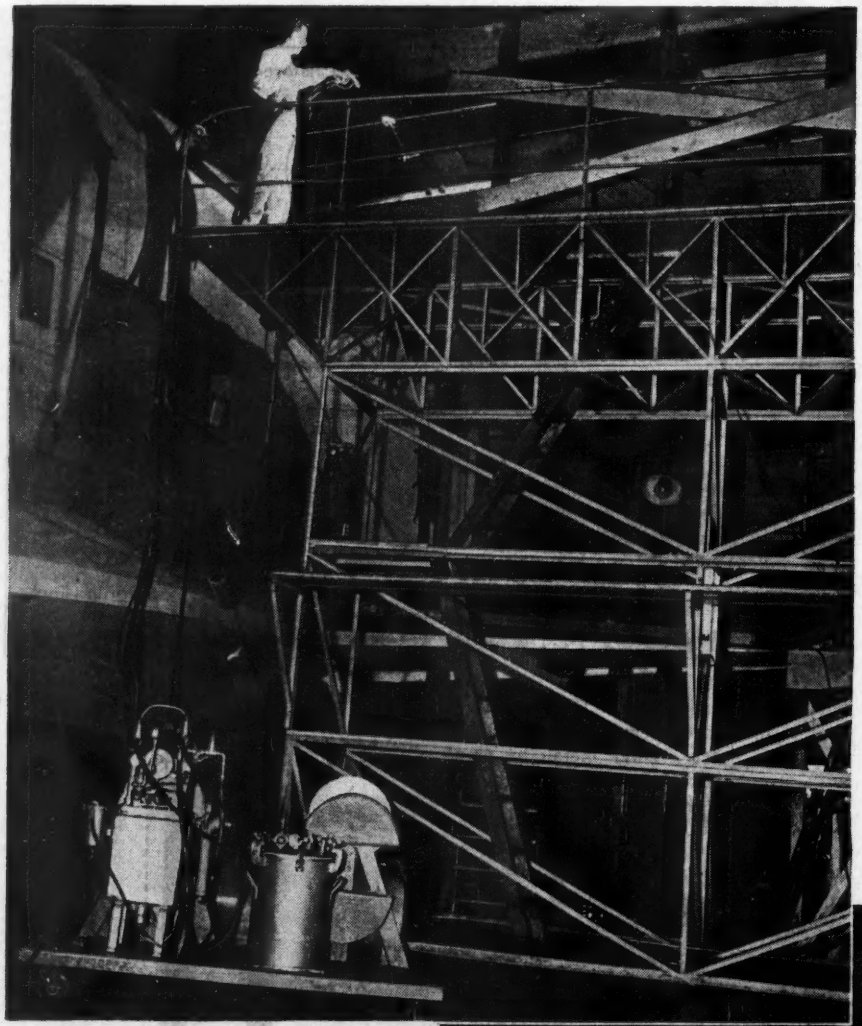
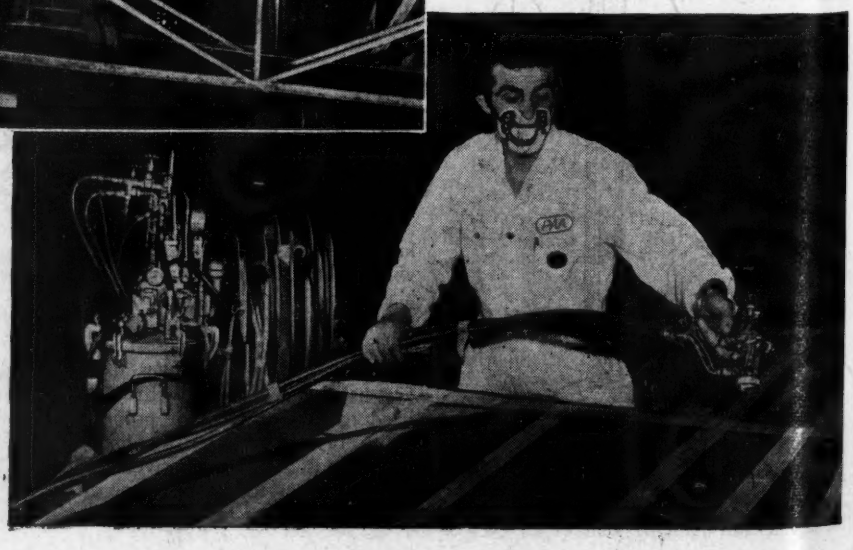
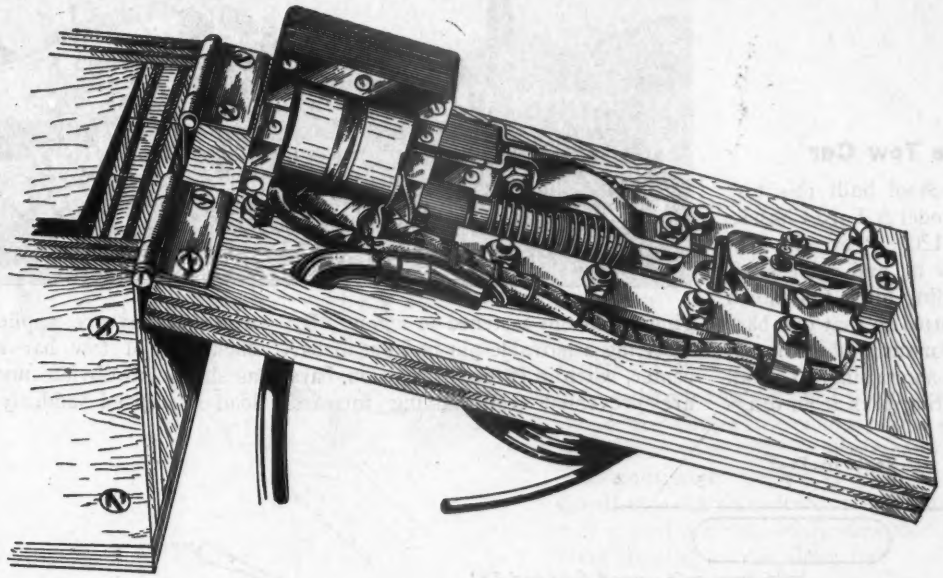


Two lines—supply and return—are used for hot-doping by worker on Pan American Clipper. (PAA photo.)

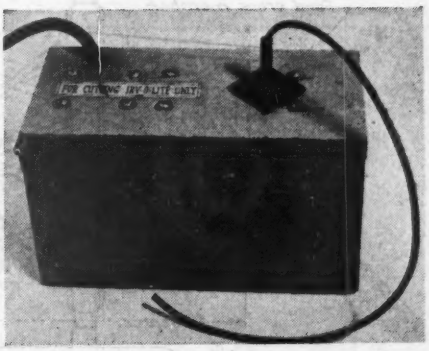


Using compar-core hose, operator sprays hot dope on fabric airplane covering. (Resistoflex photo.)



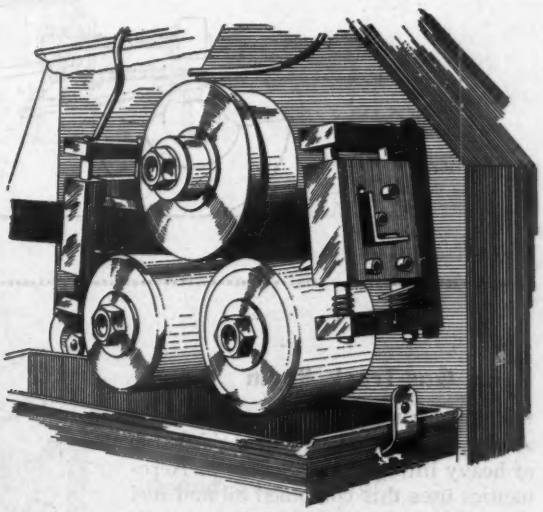
Northrop's Tubing Cutter

• Many thousand short lengths of small plastic tubing were required by the electrical department at Northrop, but cutting by hand proved very expensive. Hence, Sam D. Carter planned machine shown here in which a solenoid is used to operate a knife automatically when tubing is pushed through to cover far enough to close an electrical contact. Photograph shows box closed with plastic tubing through guide (right). Sketch shows lid open with mechanism fastened to it. Solenoid is at left, retracting spring in center, and diagonal-cutting knife at right. Contact plates are at extreme right over end of plastic tubing (shown sticking through lid).



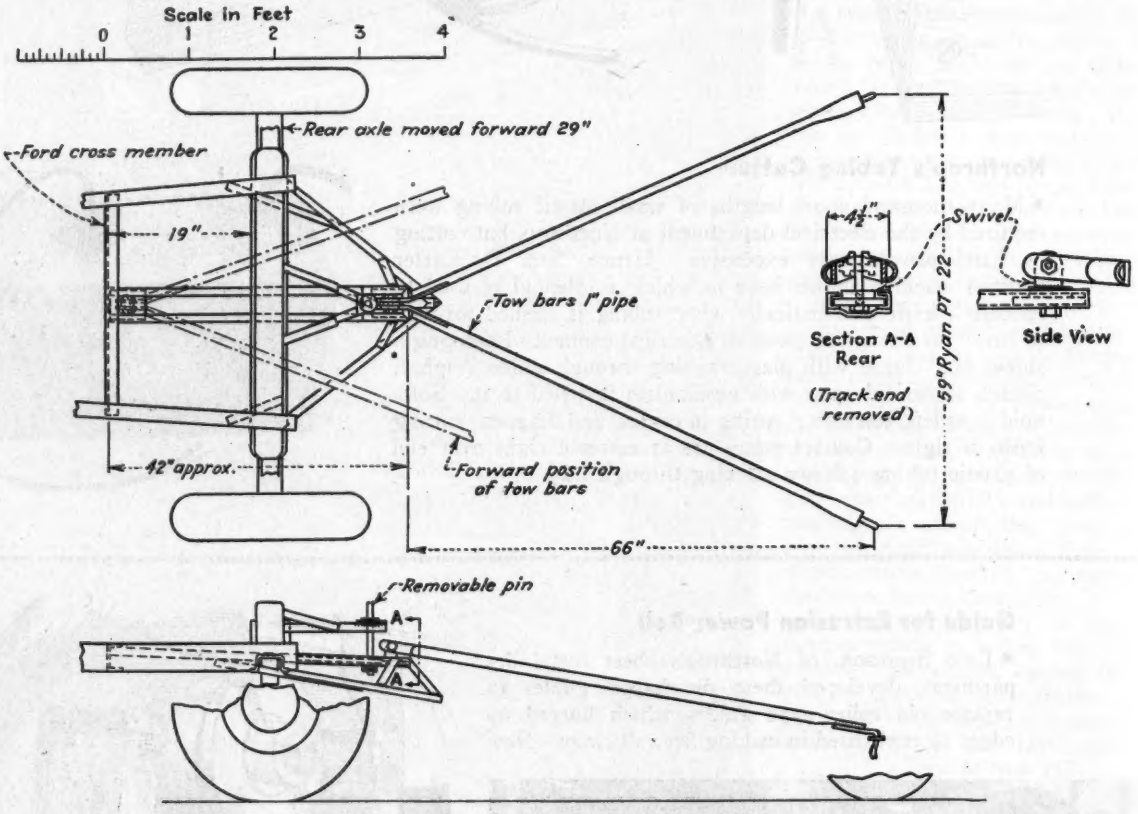
Guide for Extrusion Power Roll

• Lyle Swanson, of Northrop's sheet metal department, developed these die-shaped guides to replace old roller type guides which burred up edges of angle used in making firewall rings. New guides have free vertical movement but are held to close tolerances horizontally. Photograph shows Mr. Swanson employing guides for bending firewall rings. More than 130 man-hours per month are reported saved by this device.



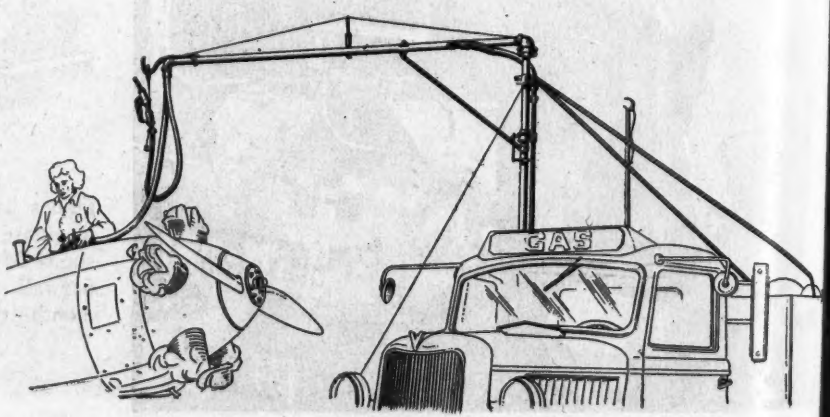
Handy Airplane Tow Car

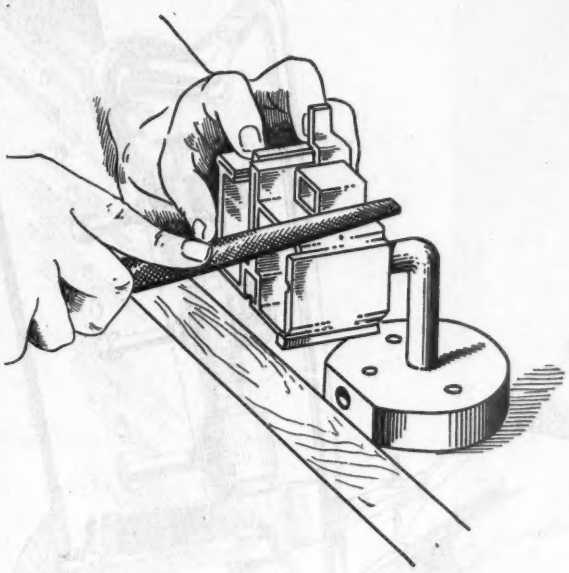
• Ryan Flying School built this tow car from an old Model A Ford Chassis. Cost was about $120. Rear axle was moved forward 29 in. and drive shaft cut off to fit. Sliding hitch (as shown in drawing) was used so that tow bars could be moved forward when not in use, thus both shortening over-all length and preventing bars from dragging when not fastened to a tow. By inserting a movable pin in front of bar center, when in extended position, bars are prevented from sliding forward when brakes are applied. Hook on back end of tow bar must be bent, as shown, to obviate uncoupling when load is stopped suddenly.



Ryan Gas-Truck Boom

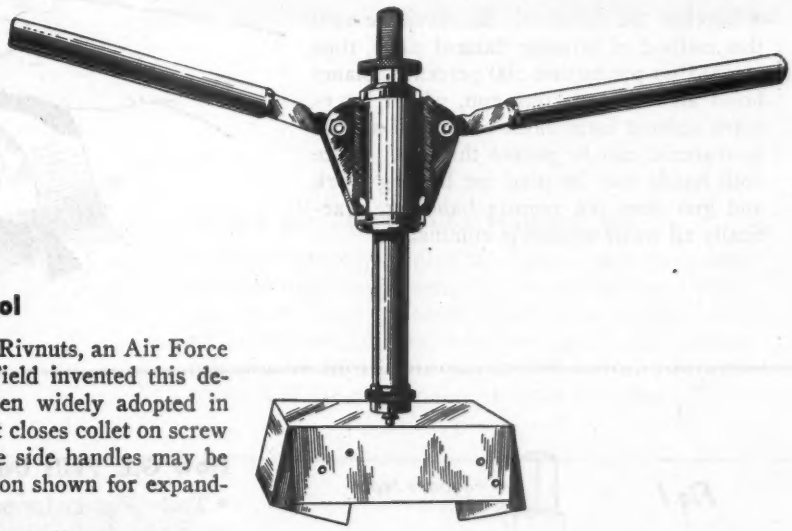
• To enable women workers to service airplanes on the line with a minimum of heavy lifting, Ryan School of Aeronautics uses this combined oil and fuel boom which permits refueling and oiling with least possible effort. Boom is fitted with leak-proof swiveling joints, and gas and oil flowmeters in truck cab enable driver to record amount with which each plane is serviced without leaving his seat. Additional advantage is that truck can drive a safe distance in front of parked planes.





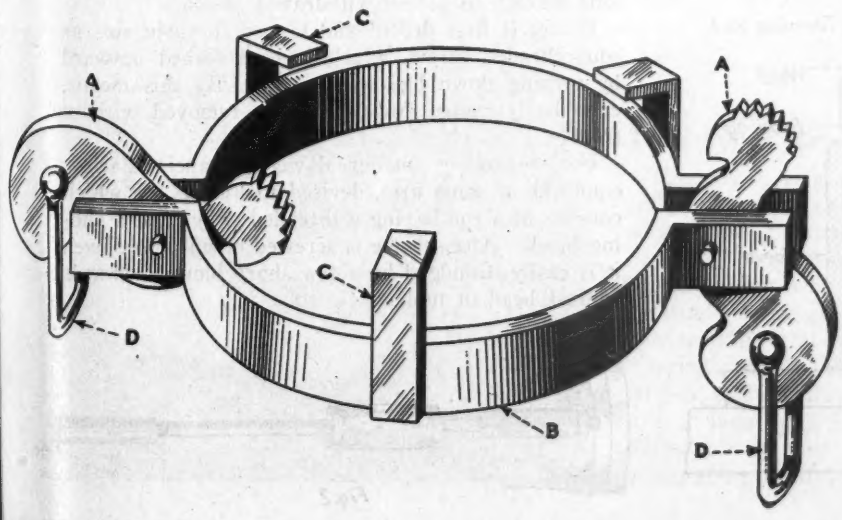
Filing Fixture

• A leading manufacturer uses this small work-supporting device to enable workers to dispense with a vise when articles are irregular in shape. Tool consists of a circular base into which is fitted a bent, shouldered rod. Small end of rod supports work, while shoulder prevents it from slipping too far along rod.



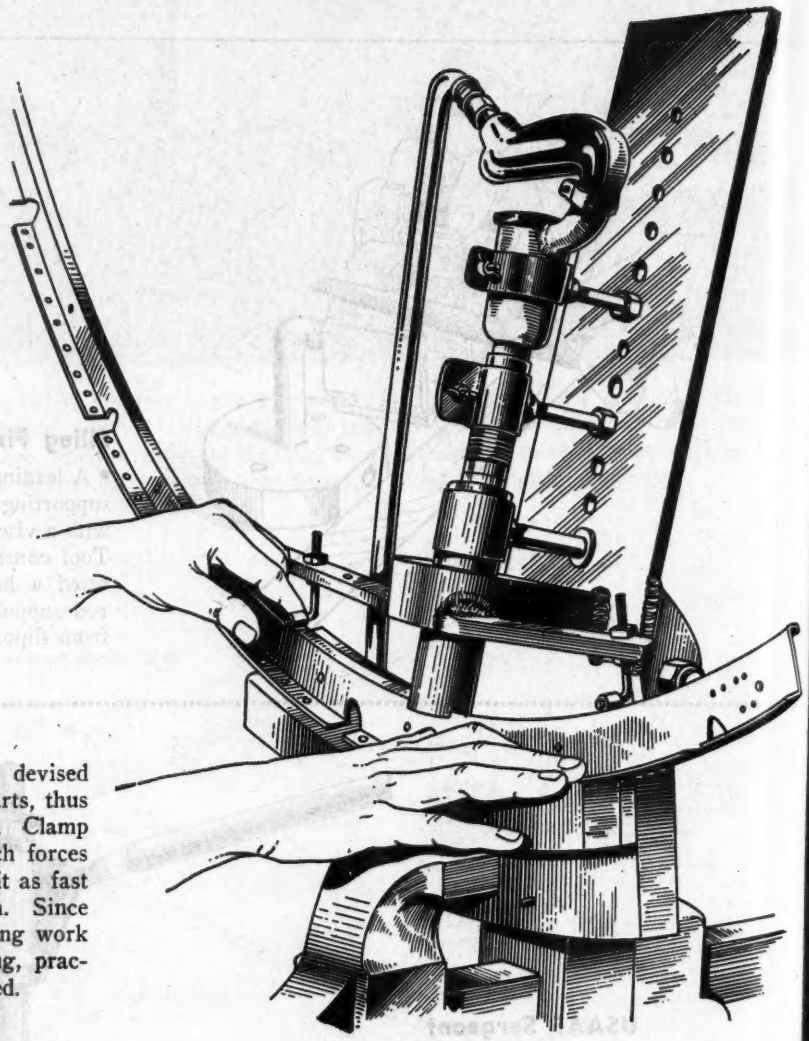
USAAF Sergeant Builds Fastener Tool

• Requiring a tool for Rivnuts, an Air Force Sergeant at Wright Field invented this device. It has since been widely adopted in AAF. Top adjustment closes collet on screw center of Rivnut, while side handles may be brought down to position shown for expanding fastening.



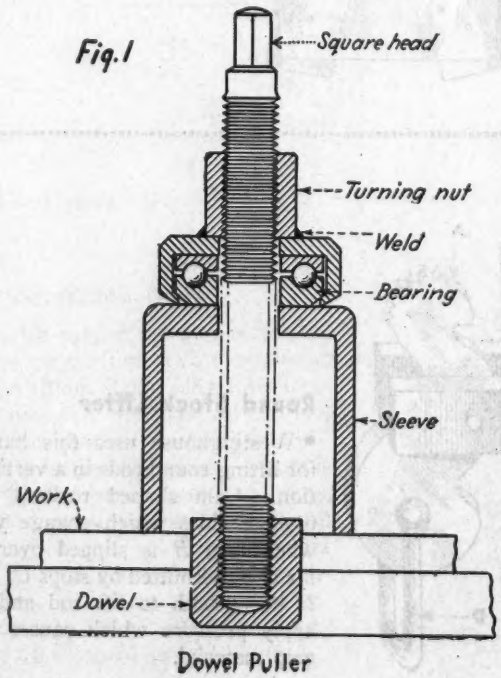
Round Stock Lifter

• Westinghouse uses this handy tool for lifting round rods in a vertical position. Cam shaped rockers *A* have toothed sides which engage with rod when ring *B* is slipped over end as far as is permitted by stops *C*. Clevises *D* serve both to lift rod and also to apply pressure which causes teeth to grip material.



Air Gun Forming Clamp

• Mitchell A. Skaff of Northrop devised this method of forming flanged parts, thus stepped up production 500 percent. Clamp holds an ordinary rivet gun, which forces work against form block beneath it as fast as material can be passed through. Since both hands may be used for holding work and gun does not require handling, practically all waste motion is eliminated.



Dowel Puller

How G.E. Pulls Dowels

• Tool (Fig. 1) for pulling dowels without damaging work was devised by Samuel Solini of General Electric. It consists of a nut into which has been inserted a ball bearing, the whole being mounted on a sleeve long enough to permit withdrawal of pin.

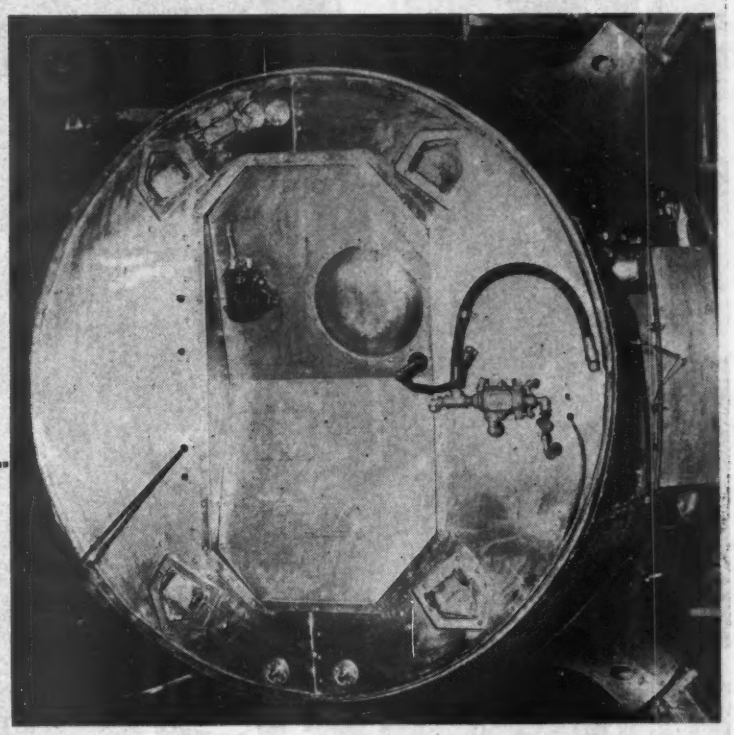
Dowel is first drilled and tapped to same size as squareheaded screw, which is then forced outward by turning down ball-bearing nut. By this means, even badly rusted dowels may be removed without trouble.

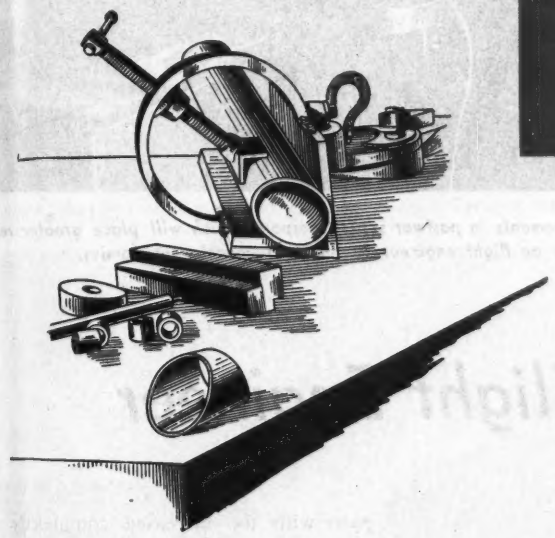
For removing smaller dowels, Francis Barton, employee of same firm, devised tool (Fig. 2) which consists of a rod having a threaded sleeve and a sliding block. After sleeve is screwed down onto dowel, it is easily dislodged by a few sharp blows outwards against head of tool.

Fig. 2

Stainless Steel Firewall

• All American Aviation fabricated this stainless steel firewall in its Pittsburgh shops when rebuilding Stinsons used in pickup service.





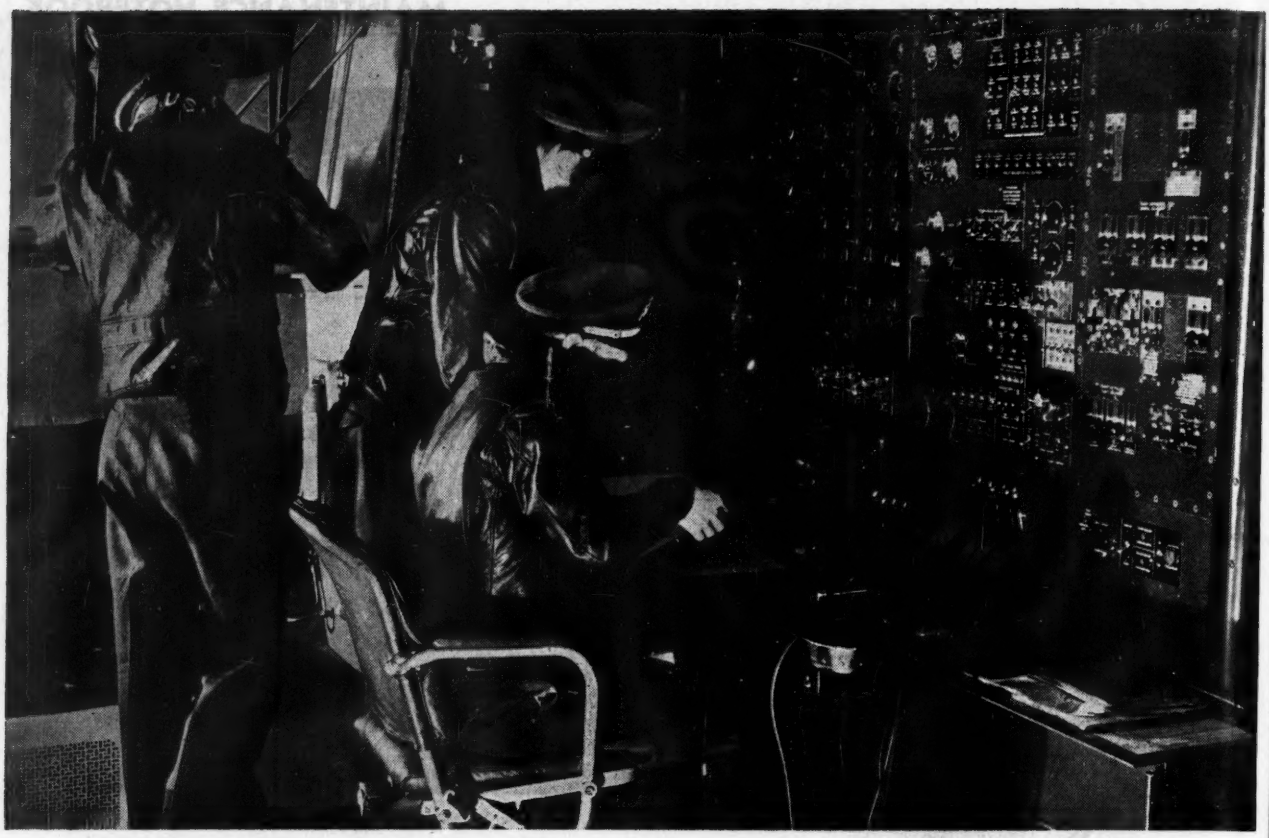
United Air Lines' Tube Holding Jig

• This fixture for holding tubing or round stock, was welded from scrap metal by a mechanic at United Air Lines' Cheyenne base. Designed to fit miter cut-off attachment of Doall machine, it will hold tubing securely for adjustment and cutting. It also permits economical use of very short lengths of tubing.

SWA Builds New Ring Grinder

• This piston ring grinder, fashioned entirely from scrap, has more than quadrupled per-operator production at Southwest Airways' overhaul depot, Phoenix, Ariz., according to Harry Barnes, engine superintendent, who designed unit. Formerly ground by hand honing at rate of 1½ sets a day, rings are now turned out at rate of six sets daily

Grinder has a table of ½-in. boiler plate mounted on ¾-in. cold rolled steel. Carried on blower bearings, it is driven by a ¼-hp. heavy duty electric motor. Rings are snapped in a holder made from an old piston skirt, then held against table's grinding surface.



Control panel of world's largest flying boat—Navy's 70-ton Martin JRM-1 Mars, pictured above, is indicative of operation technique refinements in postwar super-transports which will place greater reliance on flight engineer to reap man-machine economies.

. . . It Takes a Flight Engineer

By J. A. WAHLE and HUGH GOURDIN

Transpacific Div., Pan American Airways System

By providing the human touch, the aerial diagnostician is seen instituting flight economies saving many times his weight in fuel while, additionally, filling numerous other important roles. Here are the requirements of his job—plus a clue to how he may help in development of better airplanes.

IN BYGONE DAYS when transport flying was glorified barnstorming, and man still flew by the seat of his pants, planes were relatively simple contraptions, operated competently and adequately by a crew of one or two.

Pan American Airways, at the time it began operations, recognized a need for an expanded crew including, besides the pilot, a radio operator, steward, and non-pilot flight mechanic. Later, a co-pilot was added, and for a short period after that, a flight mechanic was still carried. However, with the planes of that day, flying ability was considered most important, hence the company started a shop course for pilots to obtain sufficient training to enable them to qualify for an aircraft and engine mechanic license.

Thus, the co-pilot fulfilled both the functions of a second pilot and of a mechanic (then no longer carried as part of the crew). As air transport was initiated to more remote bases where appropriate ground personnel was unavailable, the mechanical ability of the co-pilot began to be an important factor in the success of flight operations.

The ever-increasing demand for safe air transport, combined with an economic need for more payload miles, inevitably resulted in the development of larger, more complex, multi-engine aircraft.

Operation technique necessarily kept pace with the increased complexity of equipment, and it soon became obvious that the old-time crew of three or four would have to be augmented by individuals specializing in phases such as avigation, radio, powerplant operation, and passenger care. Thus we find that the flight mechanic then was a technician who was carried for two reasons: First, he was to perform servicing and repair at each succeeding stop, because of the dearth of adequately trained ground personnel. He usually spent part of the time en route resting, to be better physically prepared for the work ahead. Second, he was to observe powerplant operation and to manipulate certain mechanical components of the plane. The scope of the latter duty was limited to control of fuel burning (selection of tanks, etc.) and supervision of certain auxiliary systems such as heating and ventilating.

Powerplant operation was still entrusted to pilots and to automatic or semi-automatic devices. In other words, the flight mechanic was primarily an observer—the eyes and ears of the captain where the mechanical functioning of the aircraft was concerned.

Recognizing that the flight mechanic

would become increasingly important with crew specilization in larger and longer-range aircraft, the company set about to train men for this position at the same time they were developing the crews and techniques in the Caribbean laboratory for transocean air transport operation. Development of the job had reached this stage when, in 1935, the first scheduled transocean flights were inaugurated by PAA between the United States and the Orient.

It soon became obvious that the flight mechanic was in a particularly advantageous position when diagnosing mechanical difficulties. He was on the scene as trouble developed, was able to make any indicated manipulations, and could note all pertinent symptoms. In short, he had first-hand knowledge of the trouble as it developed, and also the necessary mechanical skill and background to interpret it to the ground crew, or, if necessary, to make the indicated repairs and adjustments himself.

Accordingly, it was not necessary to rely solely upon the usually incomplete report of a pilot, who often found himself rather busy when trouble did occur. Furthermore, the distances involved, the lack of intermediate landing areas, the need for precise cruising control, increasing complexity of newer, more advanced equipment, and the growing tendency on the part of both flight and ground personnel to place more and more responsibility upon this individual, all pointed to the need for an engineering technician of more general ability than that implied by "flight mechanic."

Thus was evolved the "flight engineer," an individual with extensive engineering and mechanical background, upon whom was placed the responsibility for the mechanical condition of the aircraft, both in operation and following maintenance.

The flight engineer was assisted in his duties by one or more flight mechanics (ordinarily flight engineers in training), whose principal concern was to relieve the flight engineer periodically in order to combat fatigue on long flights. The flight mechanic also attended to such routine matters as checking fuel and oil quantities before departure, thus permitting the flight engineer to devote his time to more complex and immediate problems. These latter would include ascertaining the previous history of the airplane; what work had, or had not, been done; status of new or test equipment; planning and taking of special data; preparation of paper work; and the supervision of personnel-in-training. These items would involve conferring with personnel concerned; the inspector-in-charge, foreman of the line crew, project engineer, etc.

This, then, is the flight engineer of today, insofar as airline operation is concerned. But, what of tomorrow?

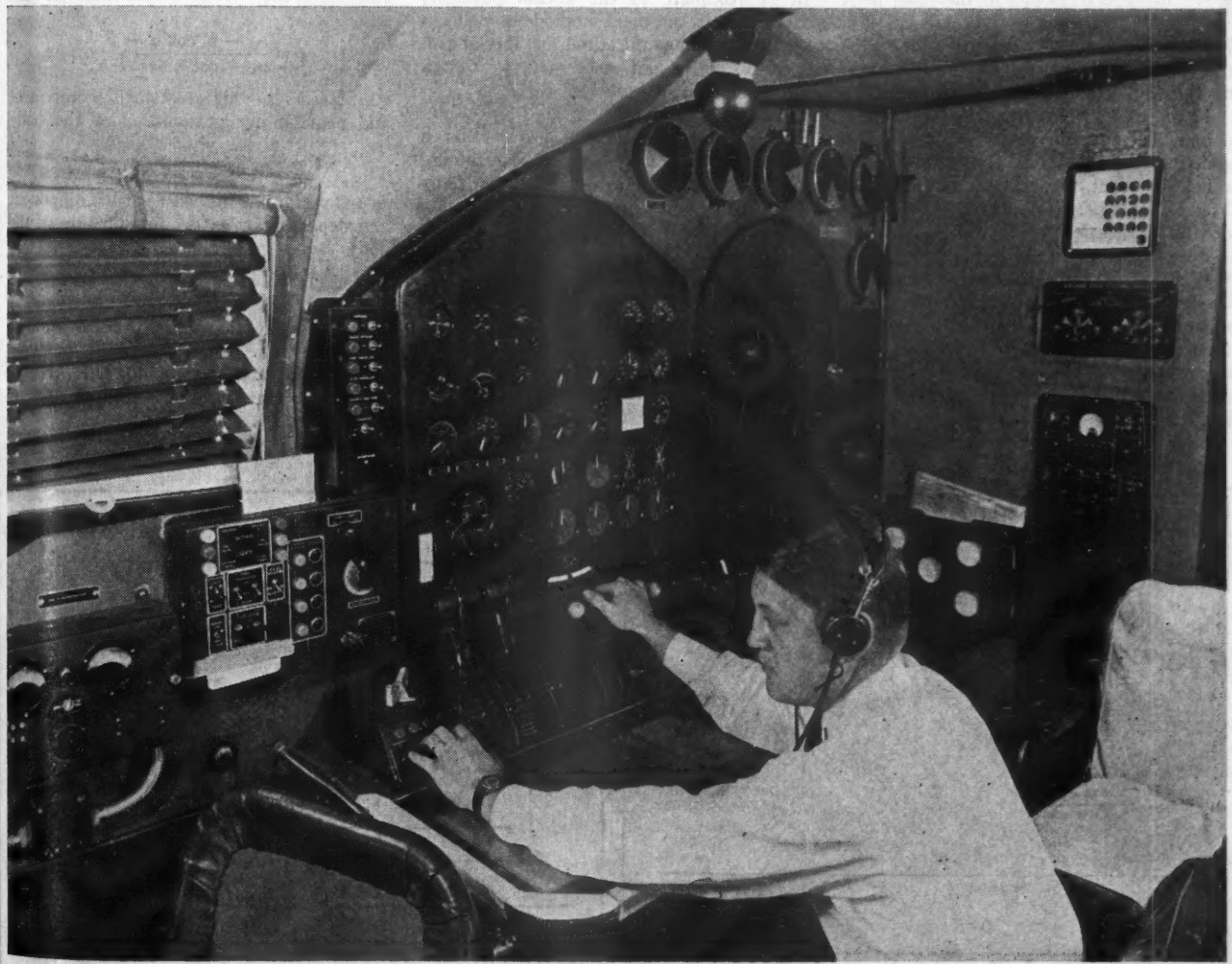
Flight Engineer of Future

As aviation develops, particularly transocean air transport, it is expected that the aircraft used will become much larger and the equipment more complex than any in operation now. Many of the manu-

(*Turn to page* 302)

Shown here in control room of Boeing 314 Pan American Clipper, Engineer Wahle adds human control (rather than automatic) for efficient operation of plane's four 1,600-hp. Wright Cyclone engines and related power plant equipment. Intimate knowledge of principles of operation and keen analysis of trouble symptoms are required for interpretation of multitude of instrument readings.

PAA Photo



ADDENDUM TO

Graphic Solutions To Celestial Avigation

By B. MATTSON COMPTON

Aviation Director, City Schools, Ogden, Utah

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Here, the writer's purpose is to propound certain formulas which, when added to the material contained in the article by Capt. James B. Rea (page 176 Mar. AVIATION), will increase the scope of its application.

Fig. 1 illustrates the general construction, using graphical methods exclusively in determining the correct time to make a latitude check and track check. Latitude is checked when the body makes upper transit and is therefore on the meridian. Track is checked when the body is abeam the track.

Note that, in this method, the true hub is used only as a device for obtaining an approximate to the abeam position; therefore, if another method is evolved for determining the time of the abeam position, it is not necessary to obtain the true hub at all.

As was earlier illustrated in Capt. Rea's article, our Fig. 2 shows that a true hub is not necessary in determining the time to make the latitude check. Any hub produced by using a sub-declination line also locates the meridian, where transit will occur, just as validly as does the true hub. This fact enables use of the graphical solution in the problem of finding the time to make a latitude check —even when the declination line of the body is off the plotting sheet and also when the true hub would lie off the sheet. No effort need be put forth to determine a true hub at all. The meridian that is passed through the hub cuts the track line and the declination line, giving positions to use in determining the time at which the flyer will be at that position on the track, or the time at which the body will be at that position on its declination line. By using either, the resulting time would be the same, being the time to make your latitude check.

The graphical solution to the problem of determining when the body is exactly abeam requires use of the true hub. If the true hub is off the plotting sheet, the method fails. Even if the true hub does lie on the sheet, often the graphical solution is disagreeably inaccurate because it is at best an approximation. To overcome these handicaps, a mathematical formula has been derived for each of the four possible conditions under which the problem will generally occur, with explanation for the fifth possible condition. The mathematical method produces accurate results, particularly when the sextant or octant reading is not less than 85 deg. and when latitude is not more than 60 deg. north or south (refer to Figs. 3, 4, 5, 6, and 7).

The four general conditions, with formulas, are as follows:

(1) Track having westward component and nearing declination line of the body

$$t = \frac{b' \cot \alpha - k}{\cot \alpha \, (n_b - n_a) - n_c}$$

(2) Track having westward component and departing from declination of the body

$$t = \frac{-\, b' \cot \alpha - k}{n_c - \cot \alpha \, (n_b - n_a)}$$

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where t is the amount of time in minutes from the time of D.R. No. 1 position. If t is positive, add it to D.R. No. 1 time; subtract it when it is negative.

(*Turn to page* 191)

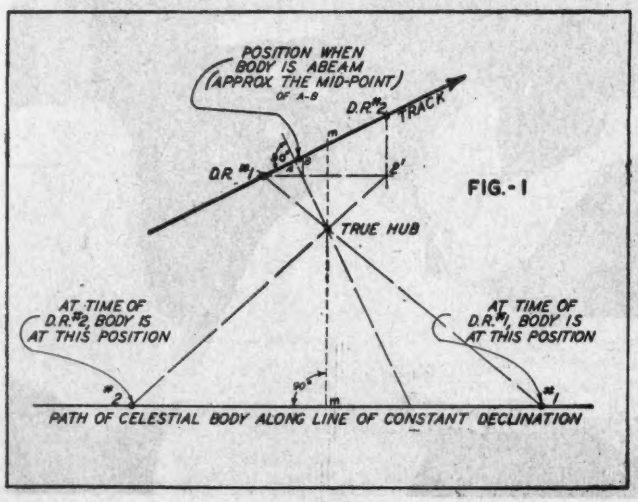

FIG.-1

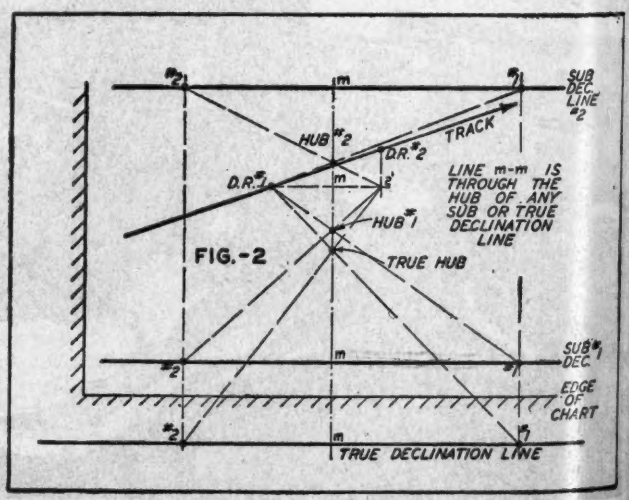

FIG.-2

The B.F. Goodrich Airplane of the month
DOUGLAS SKYMASTER
High above the Himalayas a boxcar-load of men and materials of war speeds toward a distant battlefront, borne on the wings of one of the Army's sky-giants—the Douglas C-54. This huge plane—capable of flying 14 tons of cargo across the Atlantic between dawn and dusk—is an ace-in-the-hole for the United Nations.
Despite its size, the Skymaster is known among Army and airline pilots as one of the easiest-flying and most reliable planes in existence. And B. F. Goodrich equipment helps make its high performance possible. When ice forms on a C-54's wings, B. F. Goodrich De-Icers crack it off. When pilots bring in heavy loads, B. F. Goodrich Silvertown Tires help make their landings smoother and safer. And many other B. F. Goodrich products fly with the Skymaster.
Saluting this great plane, B. F. Goodrich nominates the C-54 as Plane-of-the-Month.
In war or peace
B.F. Goodrich
FIRST IN RUBBER

ADDENDUM TO

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(*Turn to page* 191)

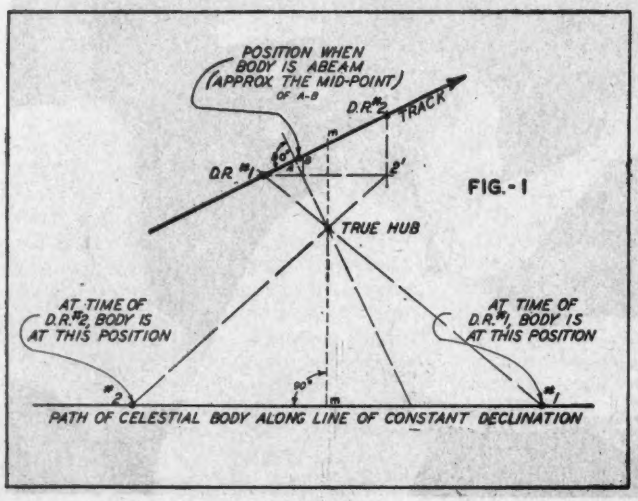
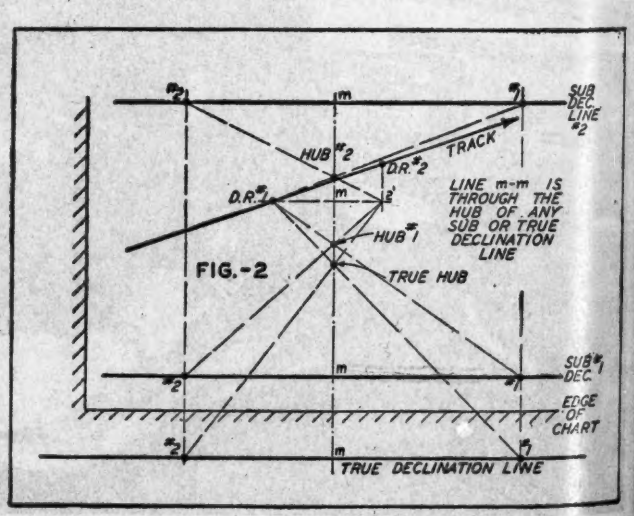

POSITION WHEN BODY IS ABEAM (APPROX. THE MID-POINT) OF A-B
D.R.#2
TRACK
D.R.#1
TRUE HUB
AT TIME OF D.R.#2, BODY IS AT THIS POSITION
AT TIME OF D.R.#1, BODY IS AT THIS POSITION
PATH OF CELESTIAL BODY ALONG LINE OF CONSTANT DECLINATION

FIG.-1



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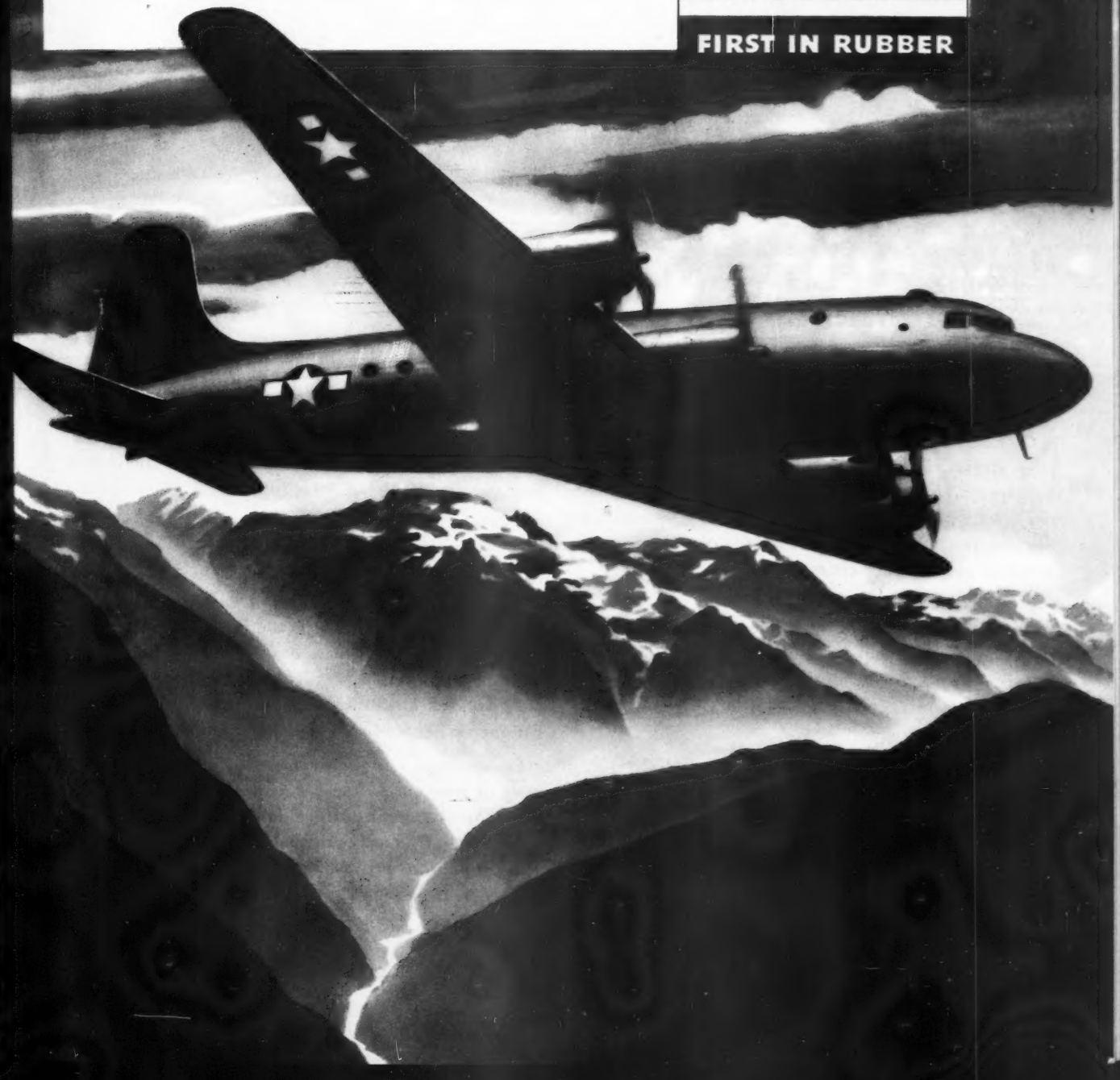
Saluting this great plane, B. F. Goodrich nominates the C-54 as Plane-of-the-Month.

In war or peace

B.F. Goodrich

FIRST IN RUBBER



"NYLONS"... for the most important ladies in the world...

NO, THIS ISN'T A STOCKING STORY. It's about tires... tires made with nylon. The "ladies" are sky queens. They're bombers loaded with every ounce they can lift—any one of the planes sowing devastation over the Reich. They're fighters, too—planes with exceptional performance characteristics.

Naturally, these airplanes are terrors on tires. A fighter really smacks the runway when it drops in at speeds up to 150 m.p.h. And a bomber—loaded to capacity—puts a terrific strain on tires when it has to taxi comparatively long distances from dispersal point to take-off strip.

Ordinary tires—even the best—weren't designed for this kind of treatment. A new tire was needed—one that would be tough enough to stand this terrific punishment yet not be any heavier. Nylon supplies the answer.

But it wasn't as simple as that. Although B. F. Goodrich research men long knew that nylon had great strength characteristics, it took months of painstaking research to overcome its drawbacks sufficiently to make nylon airplane tires practical.

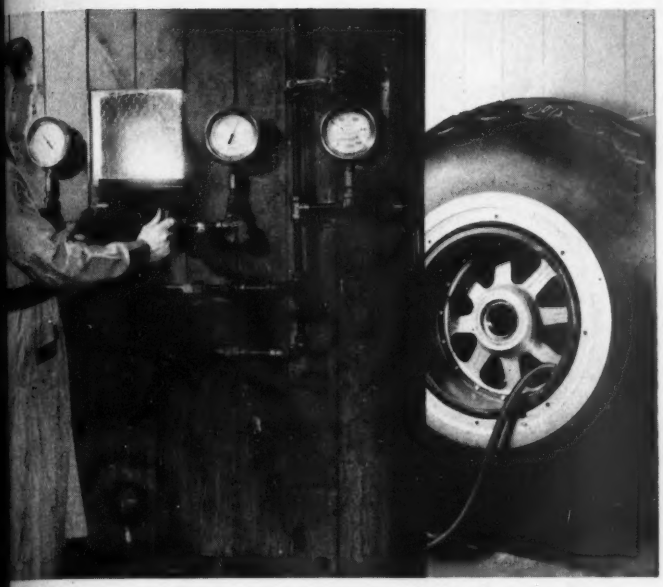
Today, nylon tires are available—although still only for use where specifically requested by the Air Corps. And they *are* successful. Performance figures—comparisons with cotton and rayon cord tires—are impressive. A good example is the B. F. Goodrich 6-ply Nylon Silvertown, which has 35% greater strength than the equivalent 8-ply rayon cord tire. Bruise-resistance is also much higher—up two to four times. Fatigue-resistance has more than doubled.

Commercial and private operators will probably have to wait until victory before they can buy Nylon Silvertowns. But the performance these tires are giving in today's war zones under the toughest kind of operating conditions proves they're well worth waiting for.
The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.

MAKERS OF B. F. GOODRICH TIRES AND OVER 80 RUBBER AND SYNTHETIC RUBBER PRODUCTS FOR AIRPLANES

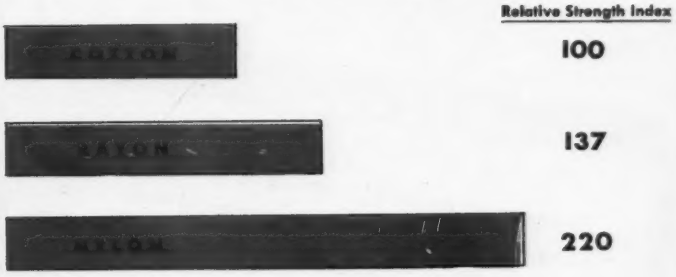
ARMY E NAVY
Awards to 9 plants

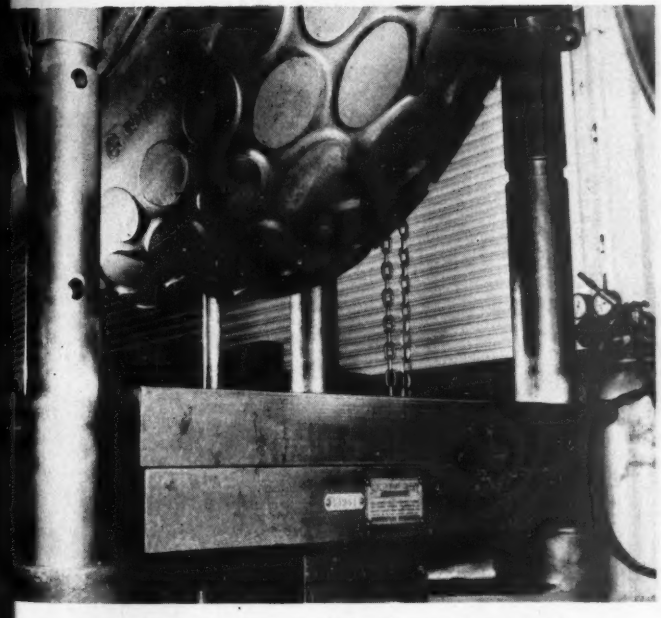
NYLON SILVERTOWNS PROVE THEIR TOUGHNESS BEFORE THEY TOUCH A RUNWAY!



Can tires take the shock when an overloaded bomber hits a bump at high speed? This test says they can. Here a Nylon Silvertown is inflated with water under high pressure until the tire bursts. The dial records a comfortable operating factor of safety for each tire type tested.

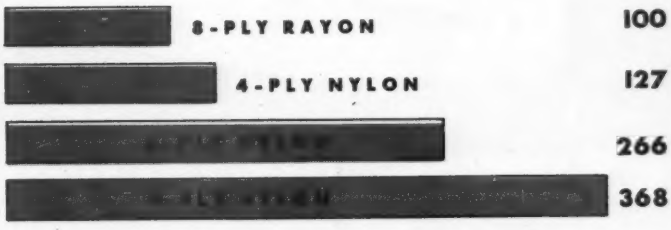
Tensile Strength Comparison of Cotton, Rayon and Nylon Cords of Equal Size





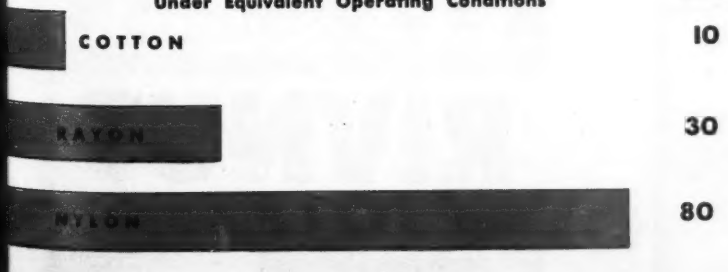
How about bruise-resistance? This test proves that overloaded bombers can do a lot of taxiing over rough fields without bruising their nylons. As the chart below shows, Nylon Silvertowns have greatly increased bruise-resistance over those made with rayon cord.

Relative Tire Bruise-Resistance at 50-Lb. Inflation



Fatigue-resistance of nylon tire cords is greatly superior to that of rayon and cotton. That's why Nylon Silvertowns stand up under the toughest kind of operating conditions. The chart here graphically shows this important nylon advantage.

Fatigue Life of Tire Cords at 300° F. Under Equivalent Operating Conditions



In war or peace

B.F. Goodrich

FIRST IN RUBBER

Plane Facts
ABOUT THE
RIVNUT

..Unique blind fastener that serves as rivet, as nut plate for attachment . . . OR BOTH!

USES . . .

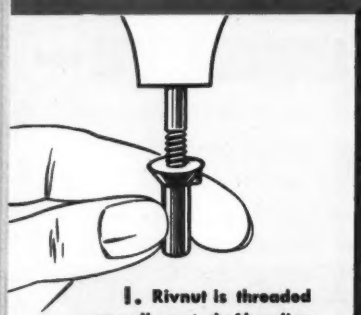
Here are some of the fastening applications for which Rivnuts are ideally suited:

- Fillets and fairing
- Door and window frames
- Access panels
- Flooring and upholstery
- Wing panel closures
- Bonding wires
- Clips, brackets, etc., for conduit
- Panel board fixtures
- Light frames

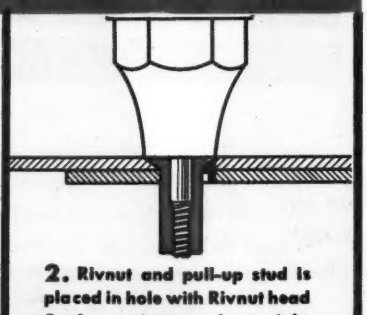
ADVANTAGES . . .

- Simple, one-piece construction of corrosion-resistant aluminum alloy
- Light weight—low cost
- Requires very small hole
- Key for high torque-resistance
- Wide bearing area
- Forms compression fit
- Ready for use "as received"
- Can be used in metal, plastics or plywood
- Head clearly marked for grip range
- Deep counterbore for easy screw insertion

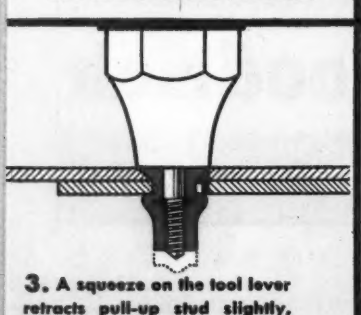
ASY RIVNUT INSTALLATION SAVES TIME...LABOR!



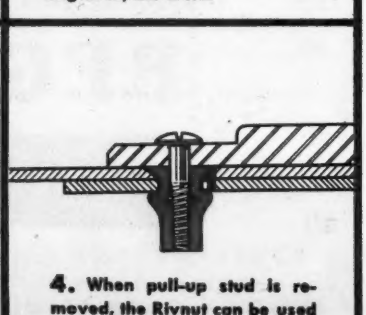
1. Rivnut is threaded on pull-up stud of heading tool until it touches the anvil.



2. Rivnut and pull-up stud is placed in hole with Rivnut head firmly against, and at right angles to, the work.



3. A squeeze on the tool lever retracts pull-up stud slightly, causing a lateral bulge upset of the Rivnut.



4. When pull-up stud is removed, the Rivnut can be used as a nut plate. Threads grip accessory screw firmly.

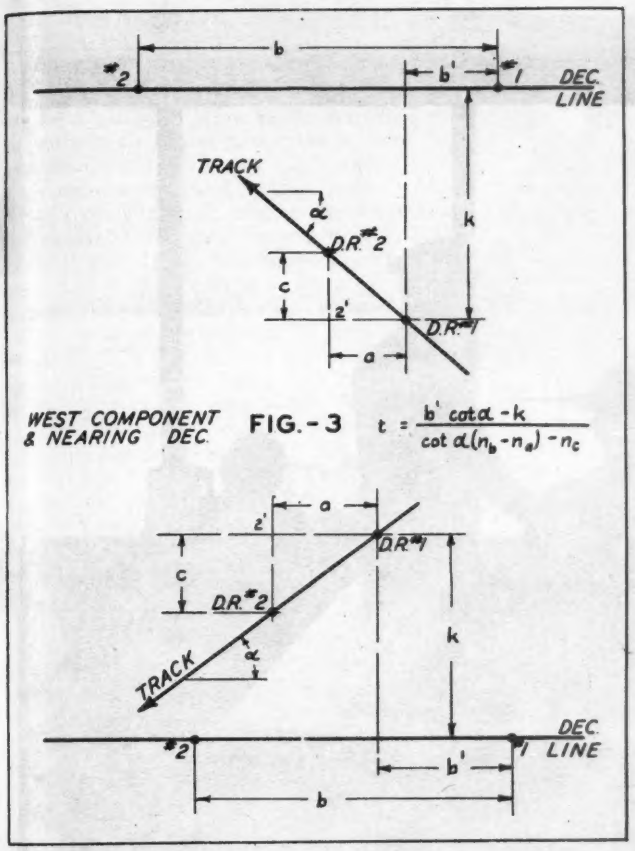
New illustrated folder . . .

Get the facts...fast...by writing today for this concise, newly edited folder. Gives full data on types, sizes, grip ranges, installation procedure. For your free copy, write to The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.

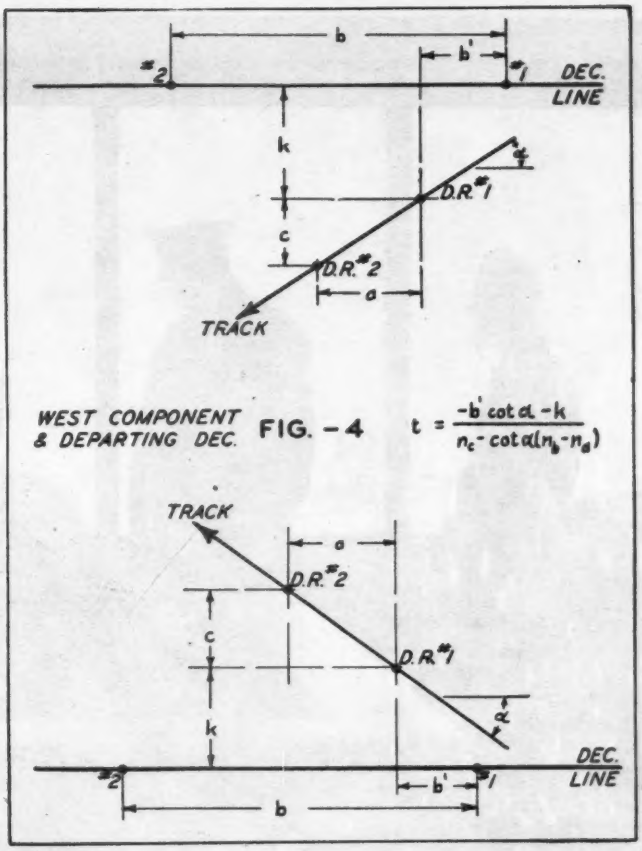
B.F.Goodrich

RIVNUT

IT'S A RIVET...IT'S A NUT PLATE



WEST COMPONENT & NEARING DEC. **FIG.-3** $t = \dfrac{b' \cot\alpha - k}{\cot\alpha(n_b - n_a) - n_c}$



WEST COMPONENT & DEPARTING DEC. **FIG.-4** $t = \dfrac{-b' \cot\alpha - k}{n_c - \cot\alpha(n_b - n_a)}$

The terms n_a, n_b, and n_c are obtained by:

$$n_a = \frac{a}{t_n}; \quad n_b = \frac{b}{t_n}; \quad n_c = \frac{c}{t_n};$$

where t_n is the interval of time between D.R. No. 1 time and D.R. No. 2 time.

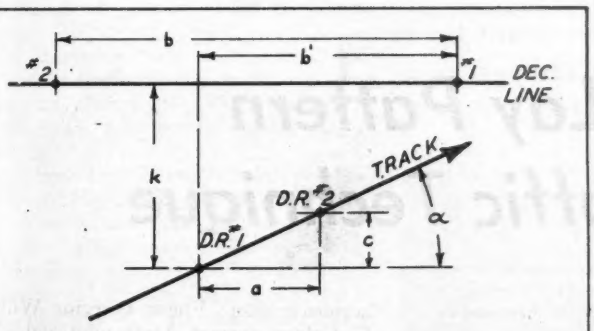
When the track happens to be exactly east or west, the special formulas below apply. Note that these are simpler than the previous ones. The terms in the formulas mean the same as above.

(5) Direct east track

$$t = \frac{b'}{n_b + n_a}$$

(6) Direct west track

(*Turn to page 257*)



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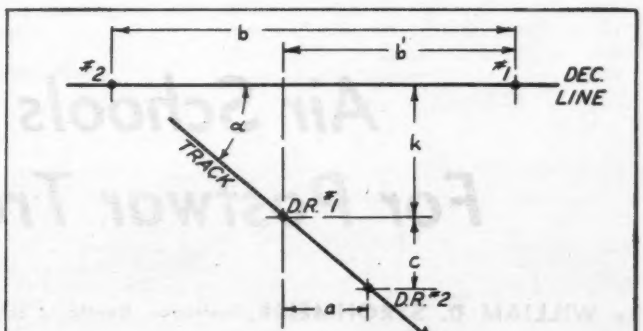

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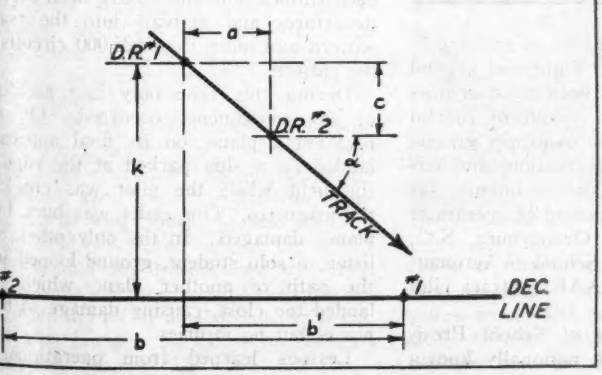
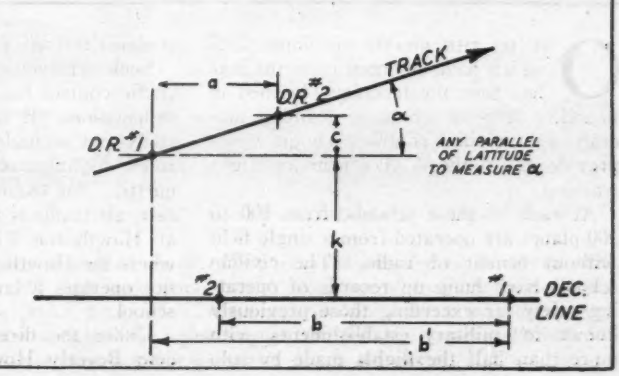




Airdrome officer (center) at Hawthorne School of Aeronautics keeps eye on all traffic and reports infractions of regulations. Lower class cadets (one is at left) spend several hours on duty to observe pattern flying from vantage point of tower. Responsible for school's safety record are: Flight Director W. G. Catron (left of A.O.) and Maj. W. A. Buechner, C.O. (right of A.O.).

Air Schools Lay Pattern For Postwar Traffic Technique

By WILLIAM D. STROHMEIER, *Instructor, Hawthorne School of Aeronautics*

Wide wartime experience in directing many hundreds of airplanes in and out of compact training fields has provided framework for orderly control of future large-scale civil plane operations.

ONE OF THE quietly developed arts which have emerged from the war has been the technique learned in handling large numbers of training aircraft at the civilian contract schools which provide all of the AAF's primary flight training.

At each of these schools, from 100 to 200 planes are operated from a single field without benefit of radio. The civilian schools have hung up records of operating safety far exceeding those previously known for military establishments, with more than half the flights made by solo students in their first 65 hr. of training.

Such achievement of flight and ground traffic control has not been a hit-or-miss proposition. It is the result of careful study and promulgation of proper ground rules, flight pattern regulation, and etiquette. An example of the intense, yet safe, air traffic is the record of operations at Hawthorne Field, Orangeburg, S.C., where the Hawthorne School of Aeronautics operates a large AAF contract pilot school.

Under the direction of School President Beverly Howard, nationally known acrobatic pilot; Flight Director William G. Catron, former Army pilot and CAA inspector; and the Army staff under the command of Maj. William A. Buechner, an estimated 618,192 landings have been effected. Also, in the 31 months that the school has existed, over 3,000 cadets have been trained, and there have been 315,896 departures and arrivals into the traffic pattern and more than 625,000 circuits of the pattern.

During this time only two accidents of any consequence occurred. On one occasion a plane, on its final approach, landed on a ship parked at the edge of the field while the pilot was checking the magnetos. One cadet was hurt, both planes damaged. In the only other collision, a solo student, ground-looped into the path of another plane which had landed too close, causing damage to both planes but no injuries.

Lessons learned from operations at

Hawthorne Field and other contract schools might well serve as an example for postwar civil aircraft operations, and they definitely indicate that radio control *is not* necessary to handle heavy traffic.

For routing aircraft around the field, the standard rectangular pattern is used, modified from CAA specification as to entry and departure from traffic. The pattern is about 1¼ x ½ mi.

First turn of the pattern is made at 400 ft. and is a 90 deg. turn in the direction of traffic. If the plane is to remain in traffic, it climbs immediately to 600 ft., then another 90 deg. level turn is made into the down-wind leg. The base leg, 90 deg. to the wind-line, completes the pattern. Until recently, the first pattern turn was made at 300 ft. and the pattern flown at 500 ft., but now all altitudes have been raised 100 ft. as a safety measure.

If departure from traffic is to be made, a second 90 deg. turn at 400 ft. is made after the initial pattern turn, followed by an immediate climb to 600 ft. This altitude is maintained, at cruising throttle, until the plane is 1½ mi. from the center of the field, after which a climb can be started.

Entry is made at 600 ft. from a point 1½ mi. from the field and at 45 deg. to the down-wind leg. Traffic is joined in the middle third of that leg.

Thus all traffic within 1½ mi. of the field is flown according to a set procedure and pattern (in traffic, departing, or entering) and no other flying is allowed within this circle unless the plane is 1,000 ft. above pattern—1,600 ft. above ground.

If a returning pilot wishes to check direction of traffic, he has to fly over the field at an altitude of 1,600 ft., then fly 1½ mi. from field before coming down to 600 ft.

Until recently the problem of checking the tee at Hawthorne led to many aircraft coming over the field at exactly 1,600 ft. Since planes came in from all directions, this resulted in awkward situations where planes approached each other head-on. To eliminate possibility of collision, maintenance of an exact 1,600-ft. altitude has been discouraged and pilots have been told to come in at random altitudes, keeping the airport on their left. An idea is being considered to adopt a system similar to CAA cross-country flight level regulations whereby planes returning from the east practice area would come in at one level while ships from the west area would check the tee 500 ft. higher.

Traffic in the training area (12 mile radius from home field) is segregated through use of zones. By fortunate circumstance, the Southern Railroad, running north and south, passes adjacent to the field. An area east of the tracks is designated for lower class use only. The upper class zone, west of the railroad, is divided in half by an east-west railroad, each area being assigned to one of two squadrons.

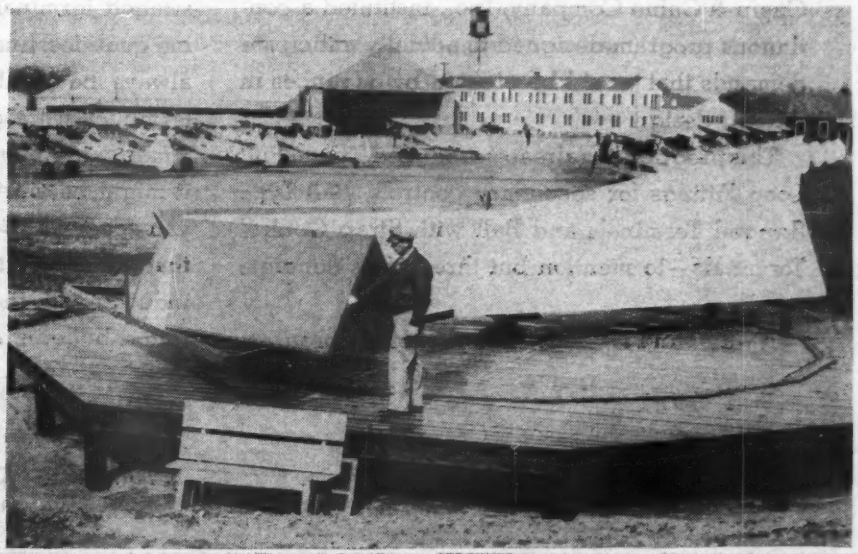
Students learn to fly pattern more accurately by studying airport model. Small wind tee may be adjusted to simulate actual conditions. Model reproduces all prominent landmarks, such as open fields, patches of forest, roads, and houses near Hawthorne Field.

Direction of traffic is accomplished by a large wind tee of standard design. To facilitate better visibility, the tee has been made exceedingly large (40 ft. main length) and is mounted on a large black platform to give contrast between the white and yellow members of the tee and the light sand of the field. The final design of the tee is the result of much experimentation and the construction of several different models.

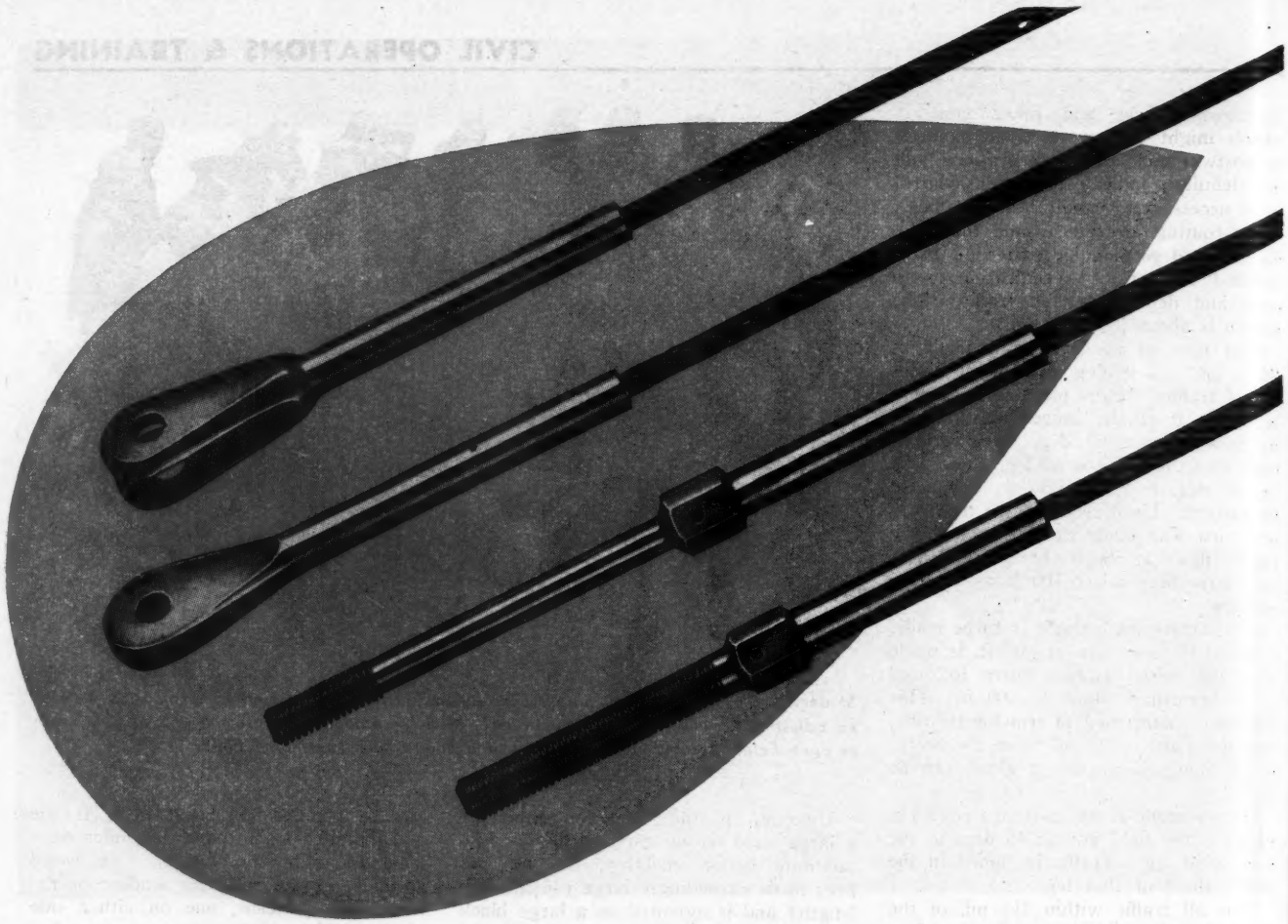
Two-Way Traffic Helps

One reason why so much dense traffic can be handled at Army fields is the fact that two traffic patterns, under most wind conditions, can be used. One would normally expect that, for student operations, two patterns, one on either side of the field, would create a menace because of the danger of students extending their base leg too far and getting mixed up with planes landing from the other pattern. Strict discipline of cadets before solo, and effective midfield markers have obviated, to a satisfactory degree, problems of this nature.

(*Turn to page 273*)



Traffic at Hawthorne Field is controlled by this 40-ft. wind tee mounted on black-top platform to provide contrast with light sand background. Direction of traffic is indicated by yellow arms, which may be folded back. Here, tee is pointing southwest to provide one-way traffic to left. Eight holes in platform, which engage locking pin, assure uniformity of direction for eight different settings. Instructor setting tee is the author.



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It was—and is—a definite part of the program to develop the so-called "standard" sleeve-type swaged terminals so that in dimensions, swaging qualities, final strength and finish they would always be right on the beam. These swaged terminals were originated and patented by the American Chain & Cable Company, Inc.—and it might be worthwhile to remember that when you specify **TRU-LOC** you get Swaged Terminals that represent the greatest experience in the industry with them. For complete data and illustrated bulletin, address our Detroit office.

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Robot Engine-Tutor Talks Back

By ROBERT I. COLIN,

Senior Instructor, Aircraft Electrical Systems Branch, AAFTS, Yale University

When engine-starting precautions aren't observed, this novel mechanical teacher "lets loose"—both verbally and demonstratively—with terse lessons which fit the crimes. And the erring novice doesn't soon forget.

EXPERIENCED AVIATION TEACHERS know that when an important point or precaution is presented to students in a grave and formal manner it is often forgotten in a day. Yet, let the instructor tie in some humor with his presentation and the students remember the point long after. The AAF, recognizing this quirk of human nature, has adapted it to its own serious ends, as evidenced by the liberal use of cartoons in its Technical Orders and other publications.

The electrical branch of the maintenance engineering course for AAF aviation cadets at Yale University is concerned with teaching technical details of aircraft electrical systems. So far as aircraft ignition and starting systems are concerned, there are two precautions which cannot be emphasized too strongly. Never touch the propeller without first checking the ignition switch to see that it is in the off position, for although aircraft engines are sometimes difficult to start, at other times they may instantly kick over after a slight movement of the propeller. Some mechanics have been maimed or killed when unmindful of this precaution.

The other precaution is to turn the propeller of a radial or inverted engine several times by hand (ignition off!) before using the electric starter, to make sure that there is no obstruction due to an accumulation of oil in lower cylinders. Where there is such obstruction and the powerful starter is nevertheless set to cranking the engine, the result may be bent or broken connecting rods and pistons. Any training aid that impresses the maintenance student with the urgency of these precautions is instrumental both in saving lives and conserving vital war equipment.

A mockup of a typical aircraft engine starting and ignition system, which, in addition to its other uses, illustrates the two precautions mentioned, has recently been placed in service at the AAF Technical School, Yale University. It was designed and built by the author.

Confronting the cadets is a plywood panel about 3 x 5 ft. as shown in Fig. 1. Mounted on the panel face are actual aircraft accessories: Two magnetos, two rows of nine sparkplugs, an electric inertia starter, a battery relay, and a booster coil. Also on the front (placed separately to simulate an actual cockpit installation)

(*Turn to page 270*)

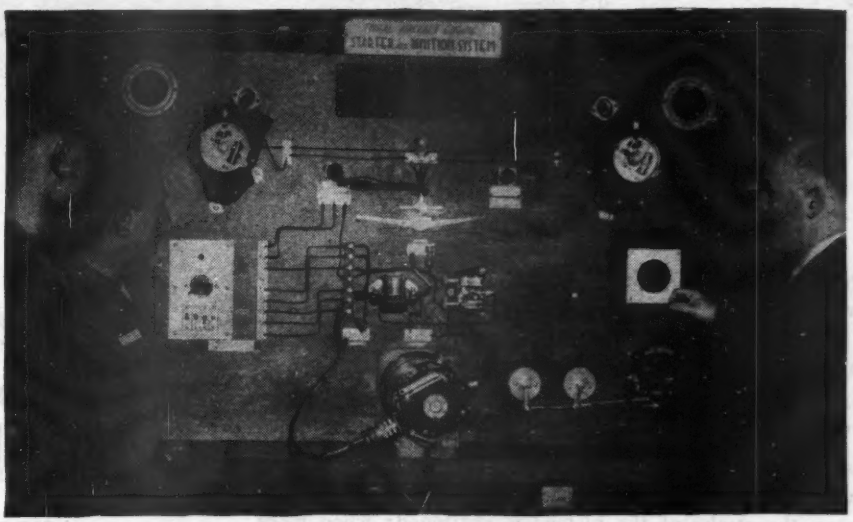


Fig. 1. Front face of mockup panel of "typical" aircraft engine starting and ignition systems, showing magnetos, sparkplugs, electric inertia starter, and associated units, switches, and controls. Wiring is visible to permit study and tracing of circuits. Mockup was designed and built by the author (right).

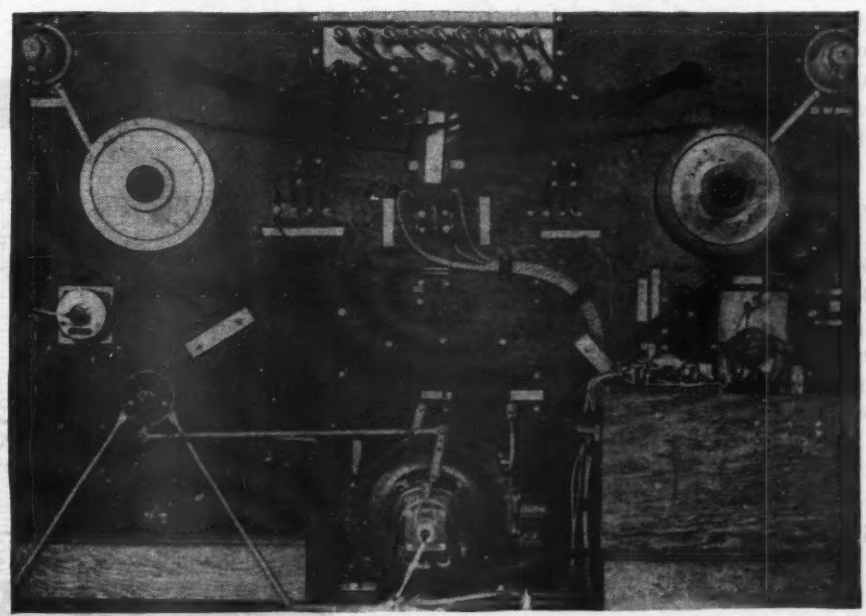
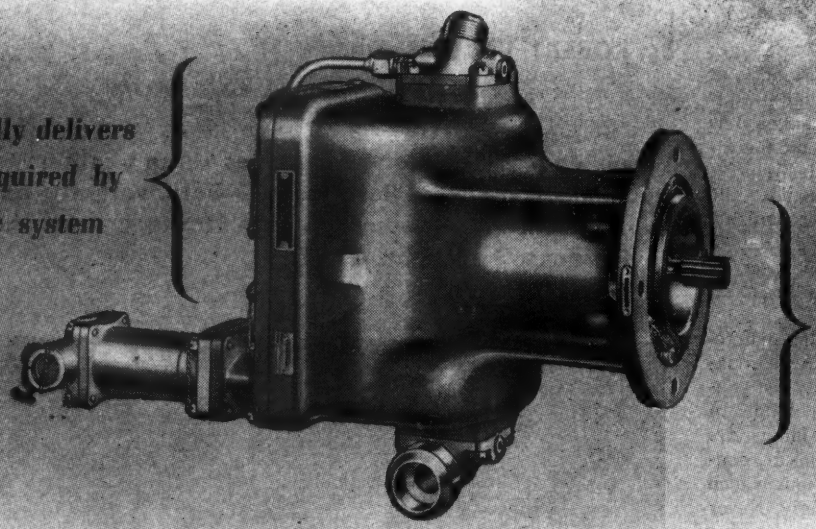


Fig. 2. Rear of mockup panel. A 110-v. motor, with linkage to vary speed, simulates aircraft engine.

HYDRAULIC POWER

FOR *Lockheed* CONSTELLATION



Automatically delivers volume required by hydraulic system

Automatically maintains pressure regardless of volume and engine speed

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This Vickers Pump automatically delivers the volume of fluid required by the hydraulic system. When the requirement decreases, the stroke of the pistons is shortened; when more volume is needed, the piston stroke is lengthened. Never is an excess of fluid pumped. The pump *maintains* full pressure in the system at all times with very little horsepower. The variable volume pump eliminates the necessity for the conventional accumulator and unloading valve required when a constant volume pump is used. The variable volume pump is recommended when hydraulic power is used continuously during flight . . . as for the flight control booster system.

As shown by performance curves, volumetric efficiency and overall efficiency are very high. Maximum recommended operating pressure is 1700 psi and maximum recommended speed is 2700 rpm. Maximum hydraulic horsepower output is 15.0 hp at 2700 rpm. The range in pressure necessary to cut volume from maximum to zero can be varied to suit requirements. The maximum pressure is readily adjustable.

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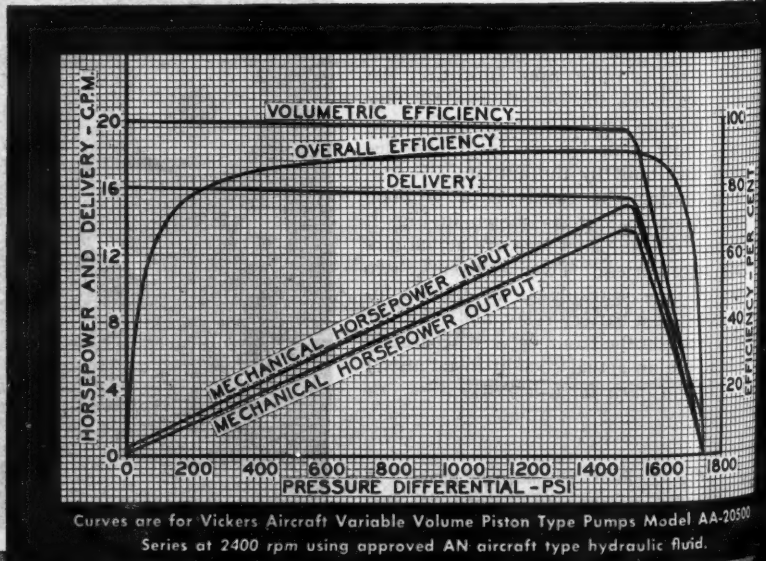
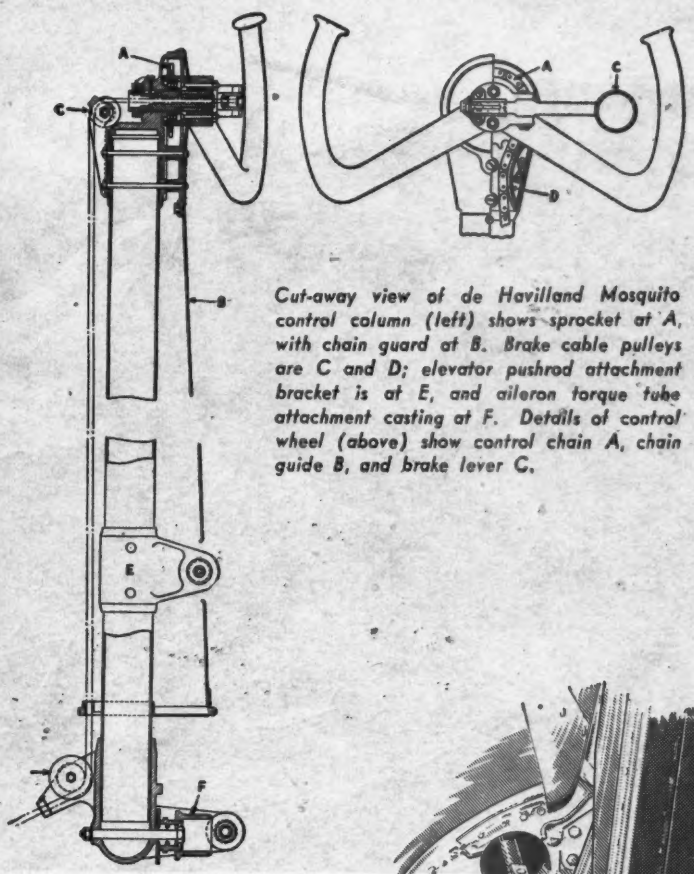
PISTON TYPE PUMPS

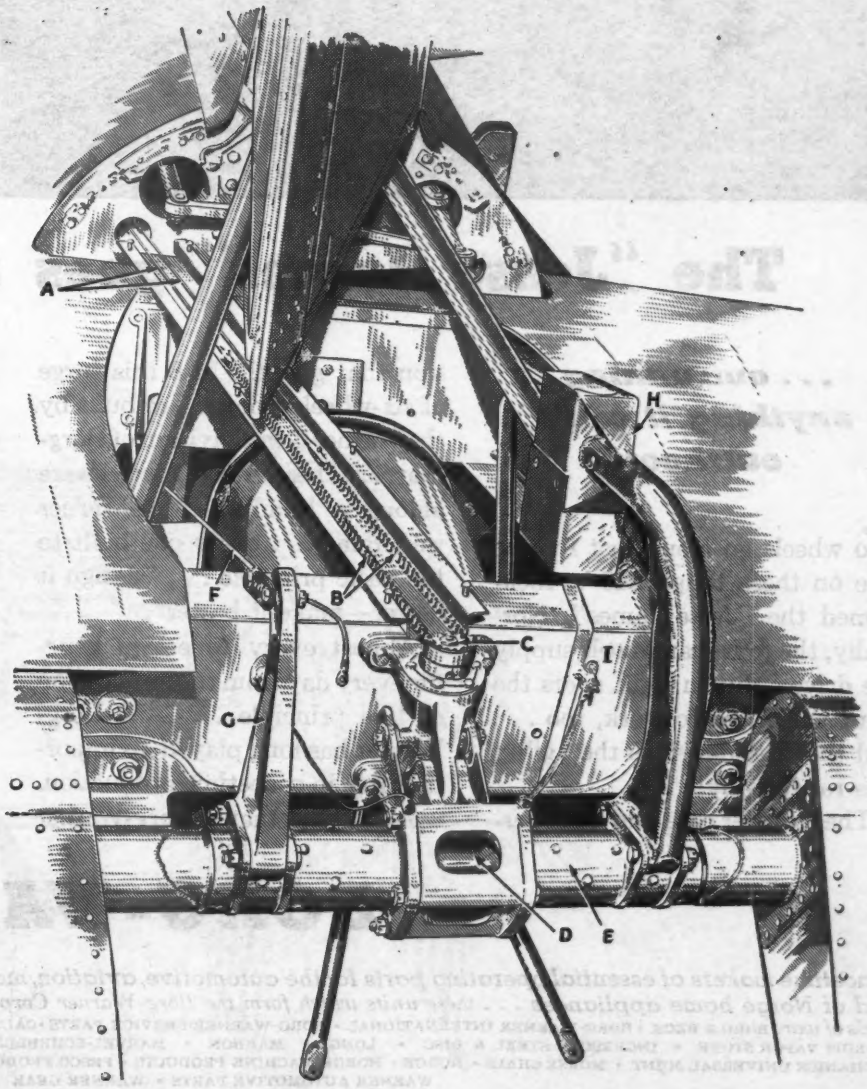


Curves are for Vickers Aircraft Variable Volume Piston Type Pumps Model AA-20500 Series at 2400 rpm using approved AN aircraft type hydraulic fluid.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



Cut-away view of de Havilland Mosquito control column (left) shows sprocket at A, with chain guard at B. Brake cable pulleys are C and D; elevator pushrod attachment bracket is at E, and aileron torque tube attachment casting at F. Details of control wheel (above) show control chain A, chain guide B, and brake lever C.



Elevator trim tab of de Havilland Mosquito is operated from cockpit through cable A attached to chain B, turning sprocket C which transmits motion to tube D, inside hollow elevator spar E. Elevator control cable is at F, horn at G. Elevator mass balance H moves down in front of rear stabilizer spar I.

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The transfer case and transmission that give the M-8 this surge of six-wheeled power are built by the Warner Gear Division of Borg-Warner. These important units are among a hundred Borg-Warner war items . . . every one built to the basic principle . . . "design it better—make it better".

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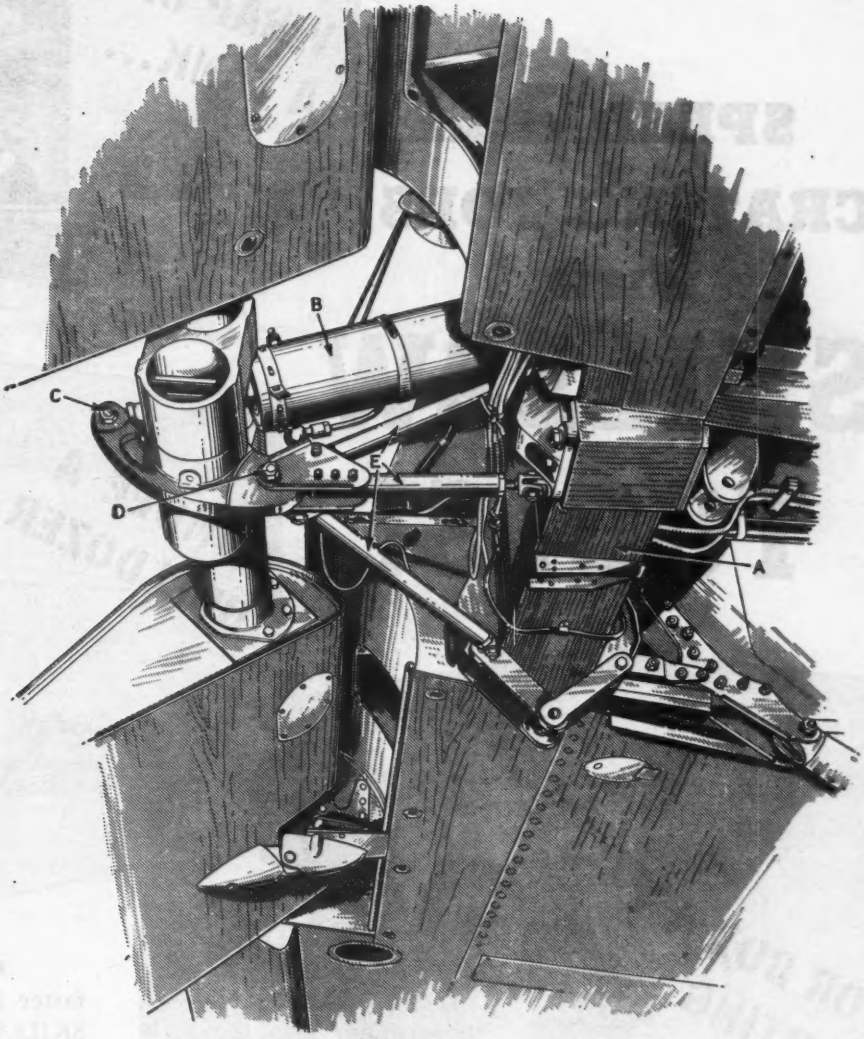
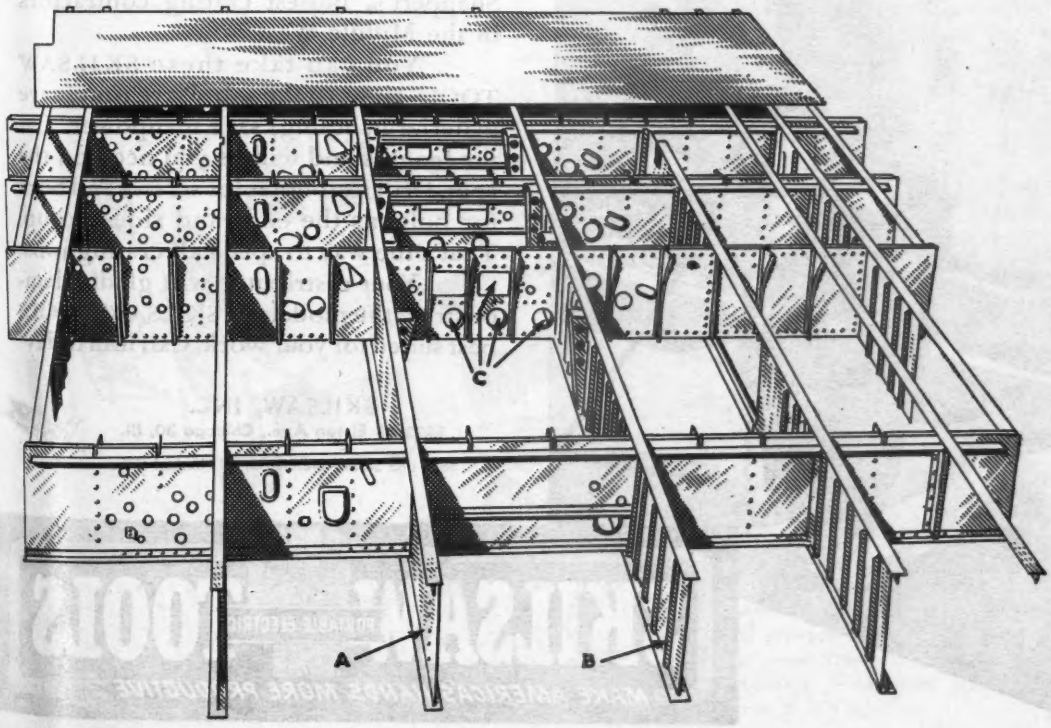


De Havilland Mosquito flap-actuating mechanism, seen from just below unit, with part of rear wing spar A visible. Operated hydraulically, actuating jack B moves piston rod connected at C. Unit pivots at D, at end of center hinge support structure E.

Cabin floor of Curtiss C-46 Commando also serves as tie-up member for upper and lower fuselage portions, which are made up of two circles with intersection at common chord line. Longitudinal members, such as A and B, are made up of flat aluminum sheet web, capstrips, and vertical stiffeners. Similar construction is followed for transverse members. Cutouts, such as at C, seen in transverse members permit passage of control cables, thus giving added space in lower cargo compartment located below floor. *(Also see page 130, Aug. 1943 "Aviation".)*



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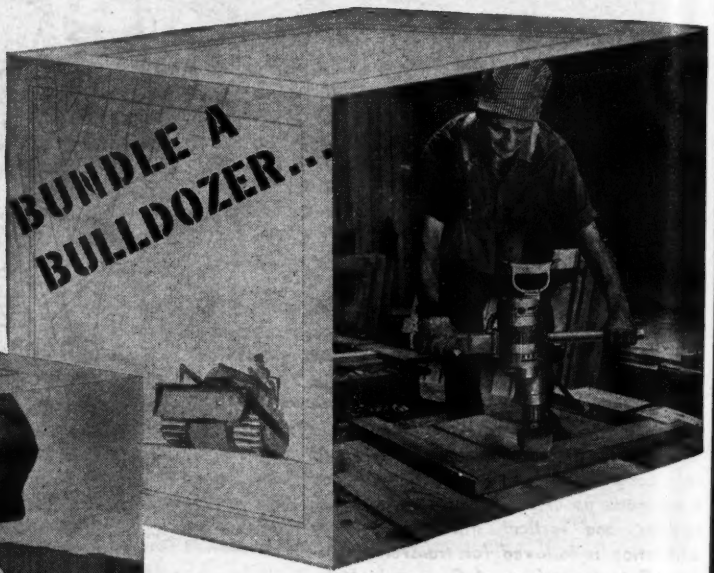

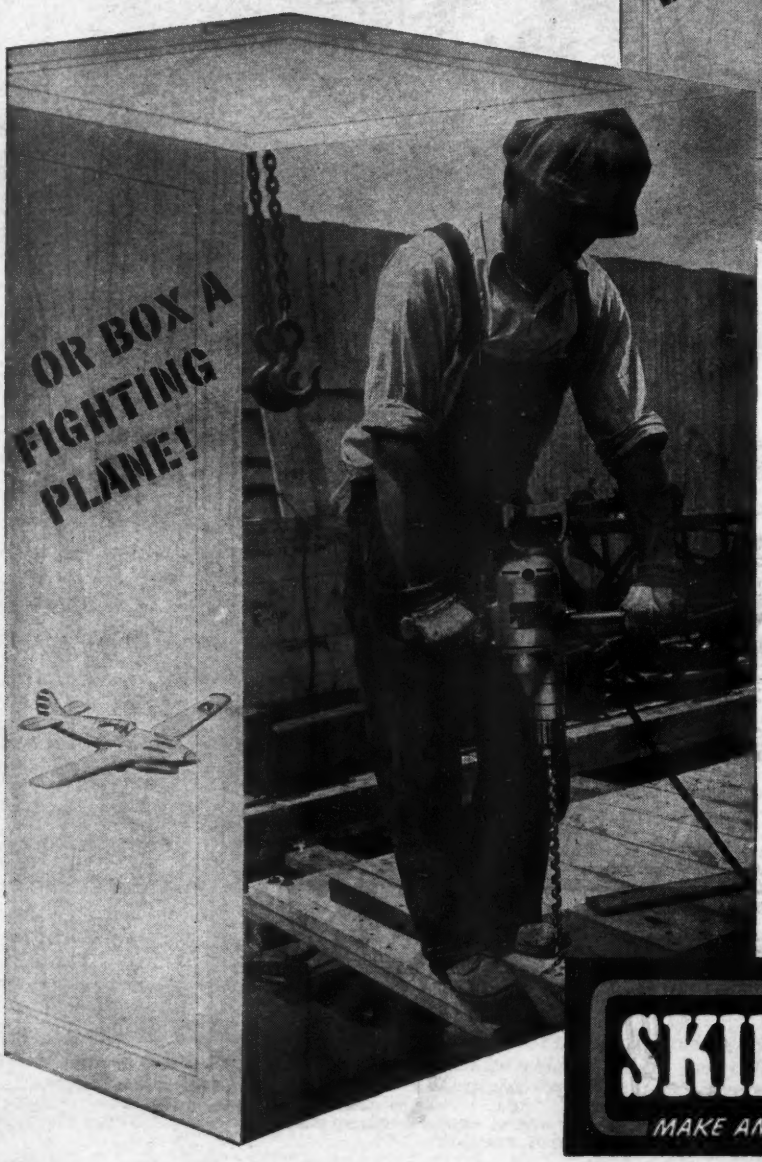

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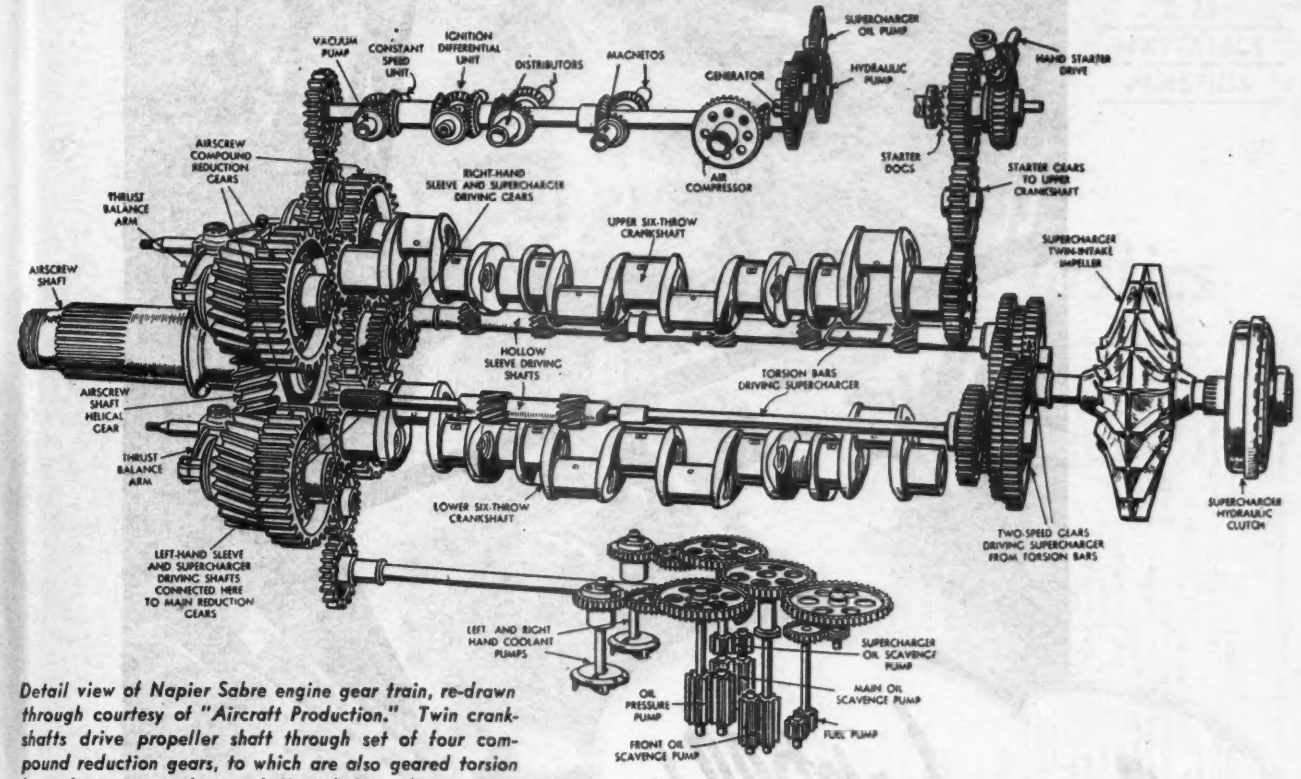
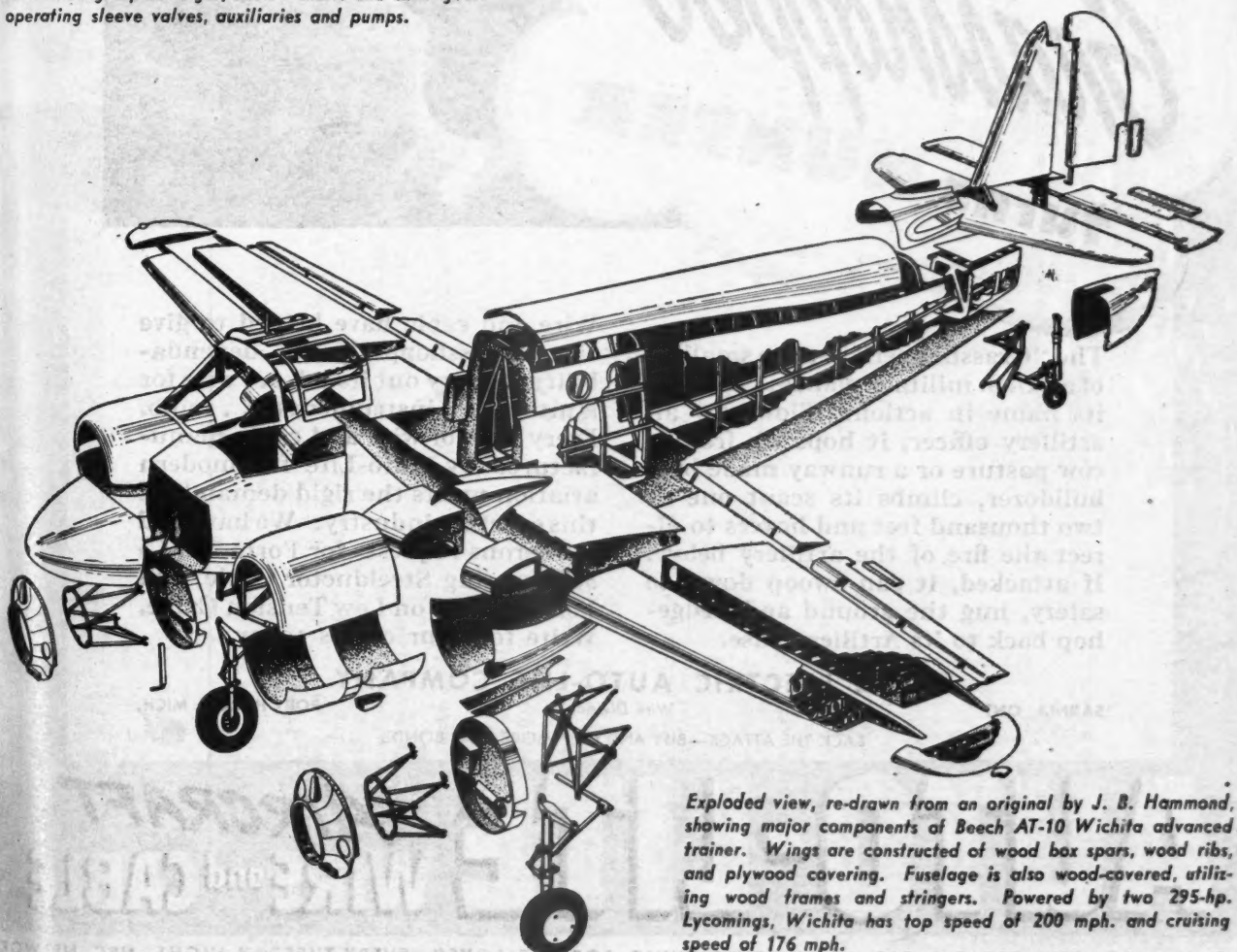


Detail view of Napier Sabre engine gear train, re-drawn through courtesy of "Aircraft Production." Twin crankshafts drive propeller shaft through set of four compound reduction gears, to which are also geared torsion bars driving supercharger, hollow shafts and skew gears operating sleeve valves, auxiliaries and pumps.



Exploded view, re-drawn from an original by J. B. Hammond, showing major components of Beech AT-10 Wichita advanced trainer. Wings are constructed of wood box spars, wood ribs, and plywood covering. Fuselage is also wood-covered, utilizing wood frames and stringers. Powered by two 295-hp. Lycomings, Wichita has top speed of 200 mph. and cruising speed of 176 mph.

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SHEET NUMBER D-23
CLASSIFICATION . . . . . MATERIALS
SUB-CLASSIFICATION . . . . . PLASTICS

General Properties Of Injection Molded Plastics

Properties	Ethyl-Cellulose Plastic	Cellulose Acetate Plastic	Cellulose Acetate Butyrate Plastic	Vinyl Chloride Acetate Plastics		Poly-Vinyl Chloride Plastic (Plasticized)
				Rigid	Flexible Unfilled	
Molding Qualities	Excellent	Excellent	Excellent	Excellent	Good	Good
Compression Molding Temp., deg. F.	300–360	260–390	260–370	280–325	250–340	290–350
Compression Molding Pressure, 1,000 psi.	1.5–5	.5–5	.5–5	1.5–2	.5–1	.5–1
Injection Molding Temp., deg. F.	350–425	340–350	340–420	280–300	250–340	300–350
Injection Molding Pressure, 1,000 psi.	3–30	8–30	8–30	18–30	18–30	20
Compression Ratio	2.2–2.5	2–2.8	2.0–2.4	2	———	———
Mold Shrinkage, inches per inch	0.001–0.007	0.002–0.003	0.002–0.003	0.001 Max.	0.025–0.100	0.016
Specific Gravity	1.08–1.18	1.27–1.37	1.14–1.22	1.34–1.37	1.2–1.6	1.2–1.6
Specific Volume, cu. in./lb.	25.7–23.4	21.8–20.2	24.3–22.8	20.7–20.2	23.0–17.3	23.0–17.3
Refractive Index, Nd.	1.470	1.46–1.50	1.47–1.49	1.53	———	———
Tensile Strength, 1,000 psi.	2–9	2.8–10	2.5–7.5	8–10	1–9	1–9
Elongation, percent	10–40	15–80	40–80	———	Up to 500	2–550
Modulus of Elasticity in Tension, psi. $\times 10^5$	1–5	0.6–3.5	0.6–3.5	3.5–4.1	———	———
Compressive Strength, 1,000 psi.	10–12	5–27	7.5–22	———	———	———
Flexural Strength, 1,000 psi.	4–12	1.5–18	2–13	12–14	Varies depending on type and amount of plasticizer	———
Impact Strength, ft. lb. per in. of notch 1/2 × 1/2 in. notched bar, Izod test	0.6–6.5	0.7–4.0	0.8–5.5	0.4–1.2	———	———
Hardness 2.5-mm. ball, 25-kg. load Brinell No.	———	6–15 10 Kg.	6–12	12–15	———	———
Hardness Rockwell	M25–M65	M25–M80	M25–M75	———	———	———
Thermal Conductivity, 10^4 cal. per sec. per sq. cm./1° C. per cm.	3.8–6.3	4.5–7.8	4.5–7.8	4.0	3.9–4.0	3.9–4.0
Specific Heat, cal. per ° C. per gram	0.32–0.46	0.3–0.4	0.3–0.4	0.24	0.30–0.50	0.32–0.51
Thermal Expansion, 10^4 per ° C.	10–14	8–16	11–16	6.9	7–25	———
Resistance to Heat, ° F. (continuous)	140–200	140–220	140–220	130	150	150
Softening Point, ° F.	200	145–260	140–250	140–150	———	———
Distortion under Heat, ° F.	120–200	105–215	115–215	140–150	———	1.70–2.50
Water Absorption, 24 hr., percent	1.0–2.0	2.0–4.7	1.6–2.1	0.05–0.15	———	0.1–0.6
Burning Rate	Slow	Slow	Slow	Nil	Dependent on type and amt. of plasticizer	Nil
Effect of Age	Slight	Slight	Slight	None	None	None
Effect of Sunlight	Slight	Slight	Slight	Darkens on prolonged intense exposure	Slight fading	Slight
Effect of Weak Acids	Slight	Slight	Slight	None	None	None
Effect of Strong Acids	Decomposes	Decomposes	Decomposes	None	None to slight	None
Effect of Weak Alkalies	None	Slight	Slight	None	None	None
Effect of Strong Alkalies	None	Decomposes	Decomposes	None	None to slight	None
Effect of Organic Solvents	Widely soluble	Soluble in ketones and esters; softened or slightly soluble in alcohol; little affected by hydrocarbons		Resists alcohols, aliphatic hydrocarbons and oils. Soluble in ketones and esters; swells inaromatic hydrocarbons		Soluble in keytones and esters
Machining Qualities	Good	Good	Good	Good	———	Fair
Clarity	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent to opaque	Transparent to opaque	Transparent to opaque

(Continued on page 205)

Breeze Production holds a Post-War Promise

A Few of the Many Breeze Products in the Nation's Service

Radio Ignition and Auxiliary Shielding • Multiple Circuit Electrical Connectors • Flexible Shielding Conduit and Fittings • Cartridge Engine Starters • Internal Tie Rods • Elevator and Rudder Tab Controls • Flexible Shaft and Case Assemblies • Aircraft Armor Plate

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Today as our armed forces smash forward to secure their beachheads on the Invasion Coast, Breeze Flexible Shielding Conduit by the mile and Breeze Multiple Electrical Connectors by the thousands are but two of the many items of Breeze manufacture that are helping make Victory possible. Communications and transportation for our fighting units on land, sea, and in the air are aided every minute of every hour by the dependable performance of such vital Breeze products as Radio Ignition Shielding, Aircraft Armor Plate, Flexible Shaft and Case Assemblies, Tab Controls and Actuators and Cartridge-type Engine Starters.

Tomorrow the same production lines that were able to turn out these items in such vast quantities, and the same hands whose skill and experience engineered them, will be available to manufacture the goods of peace. And the Breeze Mark which which has become a symbol of dependability to our fighting men on world-wide battlefronts will continue to be a mark of quality on products of the future.

Breeze BREEZE

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SHEET NUMBER . . . . . D-23 (cont'd)
CLASSIFICATION . . . . . MATERIALS
SUB-CLASSIFICATION . . . . . PLASTICS

General Properties Of Injection Molded Plastics

Properties	Vinylidene Chloride Plastic	Acrylate and Methyl Methacrylate Plastic	Poly-styrene Plastic	Urea-Formaldehyde Compound Alpha Cellulose Filler	Phenol-Formaldehyde Compounds Molding Woodflour Filler	Cast No Filler
Molding Qualities	Excellent	Excellent	Excellent	Excellent	Excellent	———
Compression Molding Temp., deg. F.	220–350	280–370	275–350	290–325	280–360	———
Compression Molding Pressure, 1,000 psi.	5–5	1–3	1–5	1.5–6	2–4.5	———
Injection Molding Temp., deg. F.	300–400	325–500	375–500	———	275–375	———
Injection Molding Pressure, 1,000 psi.	10–30	10–30	10–30	———	2–10	———
Compression Ratio	2	1.6–2.2	2.0–2.3	2.5–3.0	2.2–3.0	———
Mold Shrinkage, inches per inch	.004–0.012	0.003–0.006	0.002–0.008	0.006–0.011	0.006–0.010	———
Specific Gravity	1.68–1.75	1.16–1.20	1.054–1.070	1.45–1.50	1.25–1.52	1.30–1.32
Specific Volume, cu. in./lb.	16.8–15.8	23.8–23.0	26.3–25.9	19.1–18.5	22.2–18.2	21.3–20.0
Refractive Index, Nd.	1.60–1.63	1.49–1.51	1.59	1.54–1.56	———	1.59–1.61
Tensile Strength, 1,000 psi.	4–7	4–7	5–9	5.5–7	5–8	8.5–10
Elongation, percent	10–40	5–15	2–5	———	0.6	———
Modulus of Elasticity in Tension, psi. × 10^5	0.7–2.0	———	1.7–4.7	12–15	10–15	4
Compressive Strength, 1,000 psi.	7.5–8.5	10–15	11.5–15	24	16–36	20–25
Flexural Strength, 1,000 psi.	15–17	10–15	8–19	10–13	8–15	10–42
Impact Strength, ft. lb. per in. of notch 1/2 × 1/2 in. notched bar, Izod test	2–8	0.2–0.4	0.3–0.5	0.28–0.32	0.20–0.40	0.5–0.6
Hardness 2.5-mm. ball, 25-kg. load Brinell No.	———	18–20	20–30	48–54 (500 kg., 10 mm.)	30–45	———
Hardness Rockwell	M50–M65	M60–M90	M75–M90	M110–M130	M100–M125	M65–M80
Thermal Conductivity, 10^4 cal. per sec. per sq. cm./1° C. per cm.	2.2	5–7	1.9	7.1	4–12	3.5
Specific Heat, cal. per ° C. per gram	.32	0.35	0.32	0.4	0.35–0.36	0.3–0.4
Thermal Expansion, 10^5 per ° C.	15.8	8–9	6–8	2.5–3.0	3.7–7.5	8–11
Resistance to Heat, ° F. (continuous)	160–200	120–140	150–190	170	250	160
Softening Point, ° F.	240–280	150–230	190–250	None	None	———
Distortion under Heat, ° F.	150–180	125–160	170–175	260–280	240–285	113–176
Water Absorption, 24 hr., percent	0.1	0.4–0.5	0.00	1–3	0.2–0.6	0.4–0.6
Burning Rate	None	Slow	Slow	Very low	Very low	Very low
Effect of Age	Practically Nil	Practically Nil	Practically Nil	Hardens slightly	None	Hardens slightly
Effect of Sunlight	Slight	Very slight	Yellows slightly	None	Light shades discolor	Colors may fade
Effect of Weak Acids	None	Practically Nil	None	None to slight depending on acid		
Effect of Strong Acids	Highly resistant	Affected only by oxidizing acids	Attacked by oxidizing acids	Decomposed or surface attacked	Decomposed by oxidizing acids; reducing and organic acids none to slight	
Effect of Weak Alkalies	None	Practically Nil	None	Slight to marked depending on alkalinity		
Effect of Strong Alkalies	Highly resistant	Practically Nil	None	Decomposes	Decomposes	Decomposes
Effect of Organic Solvents	Highly resistant	Soluble in ketones, esters and aromatic hydrocarbons	Soluble in aromatic and chlorinated hydrocarbons	None on bleed-proof materials		Attacked by some
Machining Qualities	Good	Excellent	Fair to good	Fair	Fair to good	Excellent
Clarity	Translucent to opaque	Transparent (90–92% light transmission)	Transparent (88–92% light transmission)	Translucent opaque	Opaque	Transparent, translucent opaque

Courtesy Elmer E. Mills Corp.

What Price Stocks Now That Cutbacks Are Here?

By **RAYMOND L. HOADLEY,** *Financial Editor, "Aviation"*

With the "bogey man" of contract termination now out in the open, the industry still seems relatively serene. But Wall Street definitely isn't—and our financial analyst tells why, giving the perplexed investor answers he can't find in stock-price tables.

ALTHOUGH aircraft stocks tumbled to new lows at the prospect of warplane cutbacks, the industry itself did not rush to the hurricane cellars.

In fact trade officials generally seem to take a much calmer view of the coming major production readjustments than does Wall Street. They are not adverse to reduced output provided the cutbacks are gradual and reasonable advance notice is given.

It would be better that way, they maintain, than to continue production of some models at full speed long after surplus stocks have been accumulated—and then be abruptly shut down, as happened in the Brewster case.

There is also an advantage to the stockholder in a gradual slide downward from the Mar. 1944 aircraft production peak despite what Wall Street may think about it. Management is given time to work out new production programs with government officials, prepare for civilian output, get started on liquidation of frozen war assets, and start the process of shrinking down to peacetime size.

Industry officials feel it was unfortunate that Brewster had to be the guinea pig in the cutback matter. But it seems that there always has to be a dramatic incident of this sort to wake Washington up and prevent duplications of such things as the Brewster episode throughout the nation.

Undoubtedly Brewster could have switched to other production in a comparatively short time—other things being equal—had its officials had reasonable cancellation notice. Arrangements with the WPB for the release of metals and other materials for either war or civilian production take time. If those things could have been arranged before the contracts were cancelled how much better it would have been for Brewster's employees and stockholders.

What effect may stockholders expect on operating results of their company this year from production cutbacks? The Bell and Douglas cutbacks, already announced when this was written, probably will have little if any effect on those companies' 1944 results. There is a feeling in the trade that some further cutbacks may develop later this year, despite WPB assurances to the contrary, if the current European invasion goes better than expected. So there is the possibility that sizable cutbacks late in 1944 might reduce fourth quarter earnings somewhat for some companies and thus possibly bring profits for the year under those of 1943.

The most recent official government estimates place 1944 aircraft output at $21,390,000,000 against $13,800,000,000 in 1943. Industry officials feel that this estimate leans heavily toward the optimistic side. It does, of course, carry the implication that no extensive cutbacks are contemplated this year.

The output of heavy and superbombers made by Boeing and Consolidated with the aid of other companies like Bell, Douglas, Lockheed and Martin, is expected to increase throughout 1944. This also holds true of longer-range fighters and light bombers produced by Douglas (A-26 *Invader* attack bomber), Lockheed (P-38 *Lightning*), North American (P-51 *Mustang*), and Northrop (P-61 *Black Widow*).

Certainly by the early part of 1945 stockholders may expect that assembly of medium bombers like the B-25 *Mitchell* made by North American and the Martin B-26 *Marauder* will be sharply curtailed. A stabilized situation in the Atlantic area probably will call for only a replacement program for European theater types of planes. That also means limited production for Republic's P-47 *Thunderbolt* and possibly Bell's P-63 *Kingcobra*.

With the fall of Germany, whenever it comes, cancellations will become general, though perhaps not quite as general in the aircraft industry as in some others. It is estimated in responsible government circles that Germany's surrender will be followed by a drop of 35 to 50 percent in military production.

So it appears fairly evident that 1945 earnings of the aircraft industry will show considerable decline from the 1942-1944 three-year average. The decline should be less pronounced, of course, in

(*Turn to page* 278)

Official U. S. Navy Photo

UNITED STATES RUBBER COMPANY

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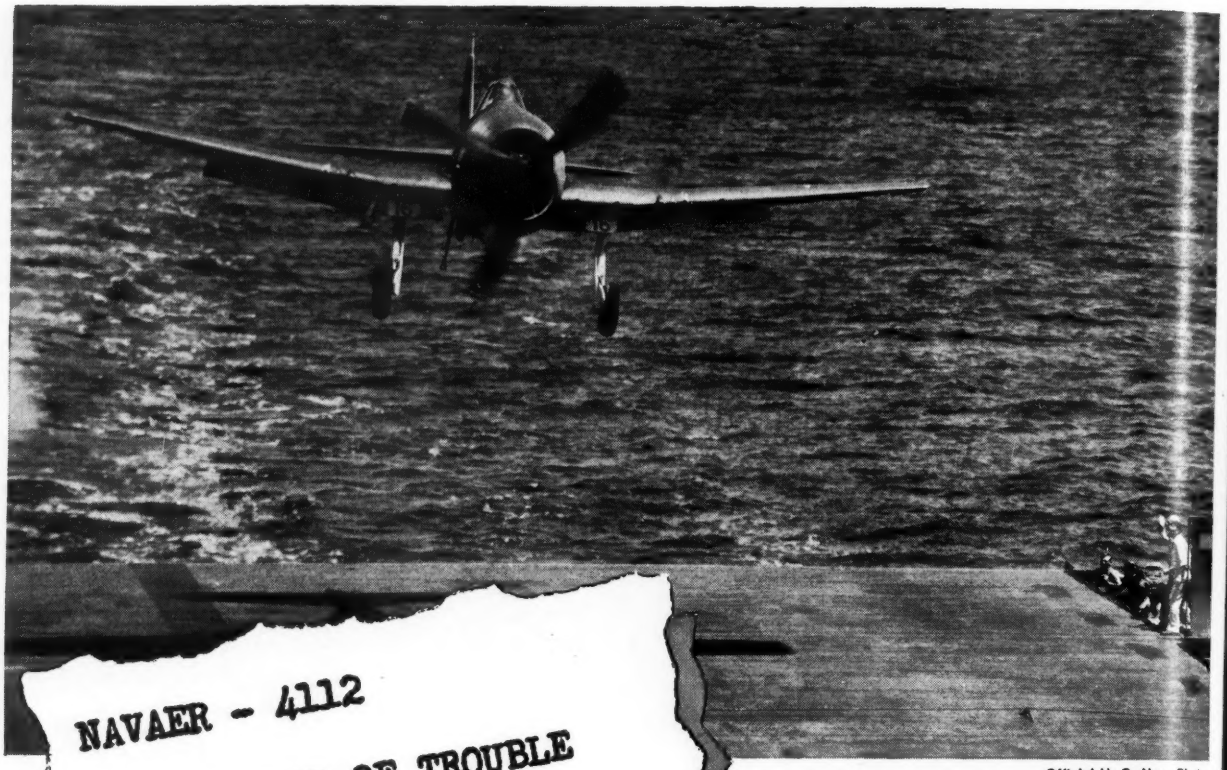
HOW THE NAVY HELPS BUILD

Reporting the Problem



Official U. S. Navy Photo

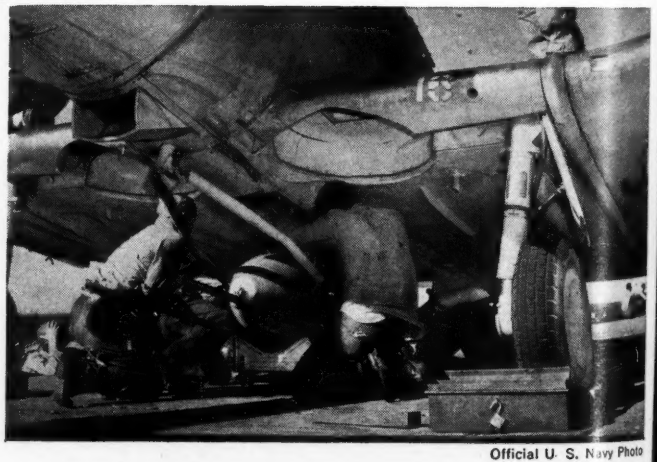
A Navy Grumman Hellcat fighter comes in for a landing on a first line aircraft carrier operating in a Pacific Fleet task force.

NAVAER - 4112

STATEMENT OF TROUBLE

...Tires are blowing out under impact of deck landing, causing sev-

Even with the most exacting care in specifications and manufacture of airplane tires and tubes, combat conditions often develop weaknesses that must be corrected; improvements that should be made to give our fliers greater effectiveness and greater safety. Through reports from combat zones called R.U.D.M. (NAVAER-4112) the Navy Bureau of Aeronautics at Washington is kept constantly in touch with all problems. When these reports are received, they are immediately relayed to all interested suppliers for quick action.



Official U. S. Navy Photo

A THOUSAND-POUND BOMB is loaded on a Navy Douglas Dauntless dive bomber about to take off. This added fighting power is another reason why the Navy's tires must be strong to carry the load and light to keep down weight.

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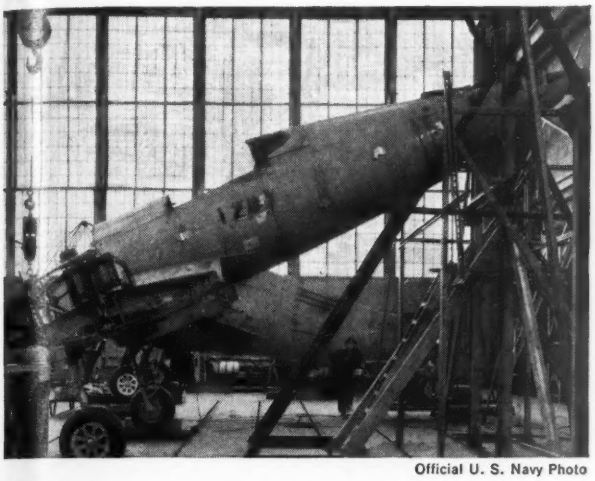
LIGHTER, STRONGER, SAFER TIRES

Finding the Answer

Not only does the Navy send its various suppliers performance reports direct from combat areas but it also constantly conducts its own laboratory and service tests. All findings that will assist manufacturers in improving their products are sent on to them for study. In this way, the technical staffs of industry benefit from the Navy's testing program just as industry's research serves the Navy.



Official U. S. Navy Photo

DROP TEST—At one of the test laboratories of the Navy Bureau of Aeronautics, landing wheels are "drop tested" on a rig like this. Here a set of landing wheel tires is mounted on the rig and dropped under full load simulating landing impact.

Official U. S. Navy Photo

DECK TEST—Actual service tests carefully supervised by Navy engineers show how the product stands up in service. On tests like this, U. S. Royal Airplane Tires—and tires of all other suppliers—must prove their ability to "take it."

Official U. S. Navy Photo

BATTLE TEST—The toughest test of all is the battle test where all rules are off—where the most extreme condition may be met, where loads are heavy and speeds are high. All the testing, all the checking, all the reporting of problems wherever they occur are parts of the Navy's precept and practice—"never waste a life."

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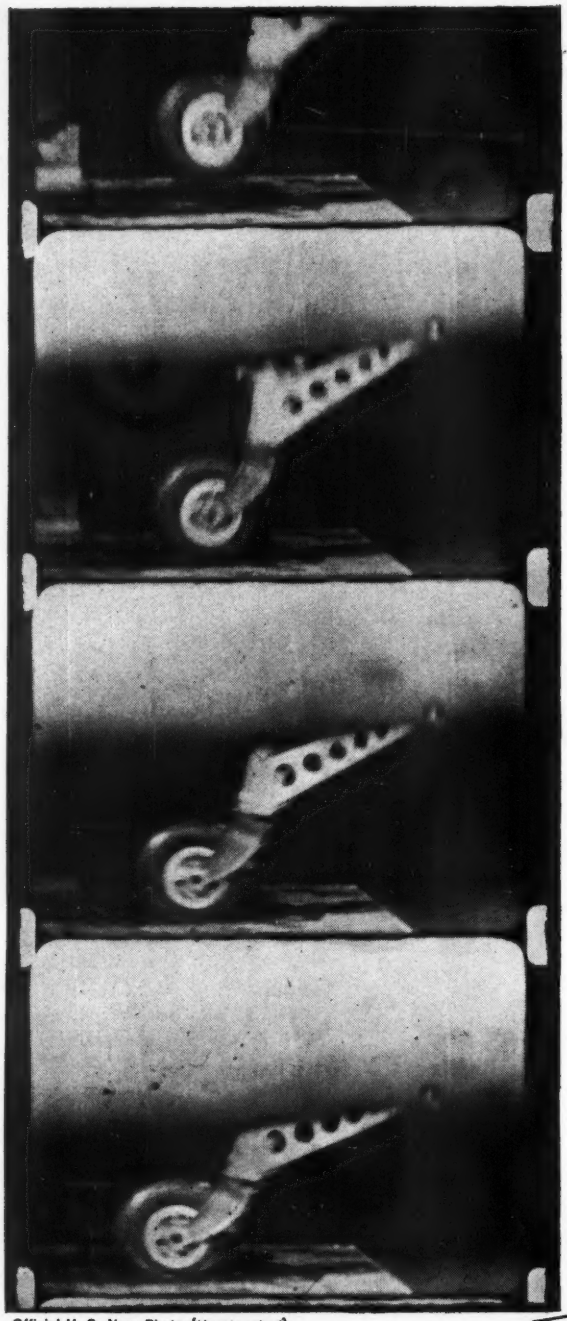

Official U. S. Navy Photo (Unretouched)

Slow motion picture

OF A NAVY FIGHTER SITTING DOWN!

This is an unretouched motion picture taken in the Navy's own testing laboratory showing what happens when the tail assembly of a Navy fighter "sits down" on a carrier deck. (Carrier landings are tail first, of course.) Under full load, the tail wheel tire strikes the landing strip and squashes almost flat under the impact. Tests like this show why tail wheel tires must be built with extra strength, extra stamina to stand the bruising "sock" of carrier deck landings.

The tests described in these pages are examples of the vision of the leaders of all our Armed Forces in providing our fighting men with the most effective fighting equipment that modern science can devise.

U.S. Royal Airplane Tires for landing wheels, tail and nose wheels, and for beaching gear are available in all standard sizes in smooth contour and high pressure types. For complete data book including full page deflection charts write on your business letterhead to United States Rubber Company at address below.

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The AVIATION NEWS

BLAINE STUBBLEFIELD, Washington HERB POWELL, New York

CPT Program Gets a Two-Year Extension; Three Developments Expedite Airfield Plans

Hinckley directs contract settlements . . . Gas rationing transfer delayed . . . "NP" plane classification recommended . . . Knudsen heads new Materiel & Services Command . . . Sell 2,500 WTS craft . . . AAAE meeting accents small port needs . . . Spin-proof "Grasshoppers" proposed.

The old Civil Pilot Training program of CAA was extended for two years by act of Congress, just prior to its expiration date (June 30). Extension of this program was urged by the various private aircraft and flight groups in order that they would have it as a nucleus around which to organize for a peacetime pilot training system.

Among these groups are the National Aviation Trades Association, National Aeronautic Association, Personal Aircraft Council of the Aeronautical Chamber of Commerce.

These people also wanted the extension as a trading point against the Army Air Forces, which has long opposed the training of pilots by civilian agencies. AAF accepted CPT only because in no other way could it meet the huge demand for trainees to build the necessary air power to win the war.

The Air Forces have no official policy on postwar training, but many of their officers have ideas on the subject. They would like AAF to exercise complete control of cadets from the first hour of primary, in West Points of the air like Randolph Field, taking one or two years of each man's time.

Civilian flying groups, on the other hand, want the job of giving primary military training, as part of the boy's education, in high schools and colleges. Opinion is that a compromise will be made, with AAF closely supervising training by civilian contractors working in public schools. Chances are that the professional air schools will participate also.

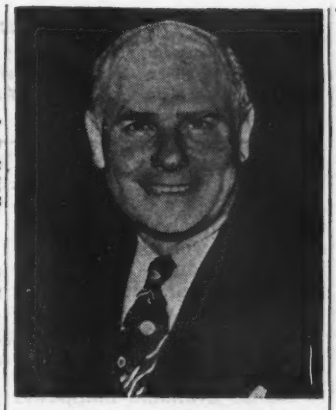
Three Moves Expedite Airfield Planning

There are three important developments in airport planning for peacetime: (1) The CAA is submitting to Congress a recommendation revising for the fifth time its master airport program, promulgated in 1939 as ordered by Congress. This recommendation is confidential until received and considered on Capitol Hill, but most observers agree it calls for airfield development by the states, matching federal funds on a basis similar to that under which the federal highway system was built.

The report probably provides also for special emphasis on fields for private aviation (schedules airlines already have most of the terminal facilities they need), for fixed base operators, and for the feeder and pickup lines which will be certificated.

(2) The Personal Aircraft Council of the Aero Chamber of Commerce proposes a four-year plan for construction of 20,000 airparks to be locally financed and built close in around municipalities. The council also calls for a system of flightstops along highways for cross-country flyers, financing to be aided by the government, and for a number of air harbors for water planes. The council believes that the future of private flying depends largely upon development of landing facilities.

(3) Rep. Jennings Randolph, of West Virginia, has introduced a bill calling for appropriation of $100,000,000 a year for 10 yr. for distribution among the states under a federal aid airport plan. Randolph's bill, if changed in accordance with CAA plans, possibly would become the Administration's legislation. Action might be taken this winter.



ROBERT H. HINCKLEY

He has been named director of Contract Settlement and chairman of Contract Settlement Board.

Coming Up

September 22: Air Transport Meeting, Institute of Aeronautical Sciences, Hotel Statler, Washington.

October 5-7: Society of Automotive Engineers National Aircraft Engineering & Production Meeting, Engineering Display, Hotel Biltmore, Los Angeles.

November 9-10: Fall Meeting, Institute of Aeronautical Sciences, Dayton.

November 13-16: National Association of State Aviation Officials, Annual Meeting, Oklahoma City.

November 15-18: Second Annual Clinic of Domestic Aviation Planning, Oklahoma City.

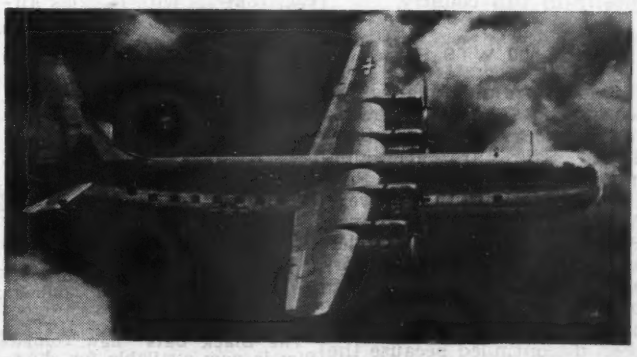
December 4-6: Society of Automotive Engineers National Air Cargo Meeting, Hotel Knickerbocker, Chicago.

December 5-7: Aviation Distributors & Manufacturers Association, Second Annual Meeting, Hotel Jefferson, St. Louis.

December 17: Wright Brothers Lecture, Institute of Aeronautical Sciences, Washington.

January 1945: Thirteenth Annual Meeting, Institute of Aeronautical Sciences, New York.

January 8-12: Society of Automotive Engineers Annual Meeting & Engineering Display, Book-Cadillac Hotel, Detroit.



"LIBERATOR LINER" MAKES BOW

First flight picture of new "Liberator Liner," Consolidated Vultee's Model 39. Slated for postwar airline service for 48-52 day passengers and 24 in sleeper version, plane uses B-24 features in 110-ft. span wing, four P & W 1,100-hp. engines, and landing gear. Fuselage is 90 ft. long (compared with B-24's 66 ft. 4 in.) and is 10 ft. 6 in. in dia. Speed is 240–270 mph., and range is 2,500 mi. with 48 passengers, baggage, and 1,200 lb. of mail. Props are Hamilton Standard. Basic gross weight is 56,000 lb., provisionally 62-64,000 lb. "Liner's" compartmentation was diagrammed on page 215 May AVIATION.

Name Hinckley to Direct Contract Settlements

Robert H. Hinckley has been appointed director of Contract Settlement and chairman of the Contract Settlement Advisory Board. This key function in domestic industrial demobilization was recommended in the Baruch-Hancock report to the President on reconversion, and was recently authorized by Congress.

Since 1942, Mr. Hinckley was assistant to the president of The Sperry Corp. He formerly held federal posts as chairman of the CAA and assistant secretary of Commerce for Air.

Opposition Delays Transfer Of Gas Rationing

At this writing a WPB order that would transfer the rationing of 73- and 80-octane

gasoline from the OPA to the CAA had been delayed for several weeks by persistent opposition of OPA and the Petroleum Administrator for War. WPB Chairman Donald Nelson, has power to order rationing by any agency he chooses, but before making the transfer he asked the opinion of CAA, OPA, and PAW.

CAA Administrator Charles Stanton replied to Nelson with a recommendation that his regional offices assume responsibility for apportioning the fuel to non-scheduled air operations in accordance with essentiality. But OPA and PAW were still arguing among themselves. OPA officials feel that transfer of this rationing program would set a bad precedent for other groups which might want special treatment.

Gasoline is already rationed by OPA's local boards, but there is no official restriction on the amount of coupons an individual can get.

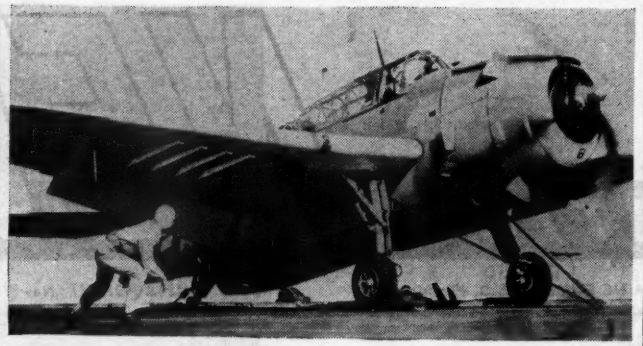
"NP" Plane-Class Favored

CAA has recommended to the CAB that a new classification—"NP" for planes used in non-commercial operations—be set so that private owners will not be under restrictions imposed upon owners of planes flown for hire. Instead of being inspected every 100 hr., NP planes would be inspected once each calendar year by a certified mechanic. Certificated pilots of private grade or higher may perform routine maintenance and minor repairs and alterations on aircraft, engines, and propellers, but major repairs and changes must still be made by certificated mechanics.

New Materiel & Services Command to Knudsen

War Department announces formation of a new Air Forces Materiel & Services Command headed by Lt. Gen. William S. Knudsen with Brig. Gen. Kenneth B. Wolfe, who has been head of the Bomber Command of 20th Air Force, as one of his deputies. Former director of production in the office of Under Sec. of War, Gen. Knudsen, as head of new division, will direct Air Forces research, design and procurement, inspection, supply, and maintenance problems from his headquarters at Patterson Field, Fairfield, Ohio.

Meanwhile a Readjustment Division headed by Col. E. V. Rawlings, a new section of Materiel Command, will establish machinery for effective handling of contract terminations, cutbacks, and disposal problems arising as a result of changes in AAF's requirements.



ROCKET-TOSSING "AVENGER"

Equipped with quadruple installations on underside of either wing to hurl rockets during flight, Grumman "Avenger" Torpedo bomber is shown here warming up on flight deck of U. S. Navy aircraft carrier. (Press Association photo.)

AAF Materiel Command has also launched a survey to determine manpower requirements and work schedules for its installations. Results will give officials current knowledge of work load encountered by all divisions, together with comparative figures on personnel requirements, in order to utilize available manpower to highest degree.

Spin-Resistance Sought In "Grasshoppers"

The Field Artillery is contemplating a change to spin-resisting characteristics in its grasshopper liaison planes used as "elevated observation posts" in fire control. Piper "Cubs" are standard equipment overseas. Officers in charge are well pleased with Piper performance and service. They seek, however, to free their pilots as much as possible from attention to flying while making observations under stress.

Proposed designs by Piper and by any other manufacturers will be considered. Aeronca, Taylorcraft, and Stinson are also used by the Artillery, but mostly in this country.

Sell 2,500 WTS Planes

Sale of training planes released from CAA's War Training Service now totals about 2,500. Sales are averaging more than 100 a week. Five thousand planes in all were purchased by the Defense Plant Corp. last year, under an executive requisition order, and lent to WTS. The WTS program, an extension of the original CPT training, has been discontinued because the Army and Navy can now handle primary training with very little civilian assistance.

The surplus planes are posted by the regional offices of CAA and are sold to the highest bidders. The former owner of any particular plane can get it back by bidding the ceiling price set by OPA.

AAAE Meeting Accents Small Part Needs

With influx of many new fixed-base members, recent Chicago meeting of American Assn. of Airport Executives put unprecedented emphasis on small airport needs and problems. In separate session, the small airport men recommended a special division within the association to deal with their interests and called for exchange of information on accounting, monthly operation statements, and school curricula.

Howard Crush, Cincinnati Lunken airport manager, was named chairman of a newly appointed committee to develop a formula for uniform airline landing fees, on basis of airport facilities and services, weight of planes used, frequency of schedules, population served by airport, and other criteria. Resolutions urged CAA operation of all control towers in interstate traffic, and legislation authorizing CAA to pool surplus military equipment usable by airports for disposal to civilian flying fields.

The 150 delegates re-elected Maj. C. E. Hanst, ATC, formerly Dallas airport manager, as president, and G. P. Moore, Peoria as secretary-treasurer. Other officers: DeSilva, Los Angeles, first vice-president; N. Brackstone, Lansing, Mich., second vice-president; Crush, third vice-president; and C. Trager, Peoria, counsel. Directors: F. Geng, St. Paul; F. Alley, Charleston, W. Va.; P. Koonce, Houston, Tex., D. Steele, Burbank, Calif.; D. Swenson, Rochester, Minn; M. Nuss, Reading, Pa., and L. Gross, Toledo, Ohio.

★ SPOT CHECKING ★

United Nations are reported to have facilities to produce more than 500,000 bbl. daily of 100-octane aviation gasoline. There are now 450 domestic refineries producing this fuel and its ingredients.

Navy announces first public testing of newest fighter, Twin-P & W-powered Grumman F7F.

China Aircraft Corp., all-Chinese manned and owned organization, has opened plant at San Francisco for parts assembly work. Project is first one where alien national set-up participates in U. S. aircraft production. Fuselage sections of A-26's will be built under one year contract with Douglas Aircraft Co.

North Carolina Aviation Week is scheduled Aug. 14-20. Highlights will include: Present and postwar planning conference, Aug. 16; assembly of North Carolina Wing of CAP, Aug. 19-20; aircraft and accessory exhibits; Army and Navy air show; and CAP competitions.

Army announces abandonment of Women's Airforce Service Pilots training program, effective upon graduation of students now enrolled. Measure to make Wasps commissioned officers had been rejected.

"The Black Cats" new combat film is now available for showing to war workers, Navy announces. Film deals with action of Consolidated "Catalinas" in Pacific.

Montana's Aviation Committee, appointed by Gov. Sam Ford, has approved "model" aviation commission bill. W. G. Ferguson, committee secretary, said bill would give commission power to regulate certifications of public convenience and necessity for interstate air operation.

Pres. John Paul Riddle, Embry Riddle School of Aviation, Miami, Fla., announces sale of his interest in school to John G. McKay, Miami attorney. Mr. Riddle said move was prompted by desire to concentrate his efforts on Technical School of Aviation which he operates for Brazilian Air Ministry at Sao Paulo, Brazil.

Long Island Association (Long Island, N. Y.) expects postwar employment in aviation on Island to treble prewar figures.

Polytechnic Institute of Brooklyn announces course in theory of aircraft propulsion will be added next fall to curriculum of graduate division of aeronautical engineering.

Training course, designed to teach Navy technicians to serve as field instructors on mechanical systems of PBM "Mariner," has been established at Martin company's service training school.

Equitable Life Assurance Society reveals data on four years' experience in treating air travel on same insurance basis as other transportation. During period, 22 claims were incurred under policies on fare-paying airplane passengers out of more than 61,000 death claims paid by Society over same period.

Engineering presentation of a new Douglas "Skybus" for postwar feeder line operations, has been made to airline presidents and government officials by company Operational and construction data on this high-wing, twin-engine, all-metal monoplane are offered in brochure.

On the booklet front: "Planning Our Future National Security" by J. Carlton Ward, Jr., President of Fairchild Engine & Air-

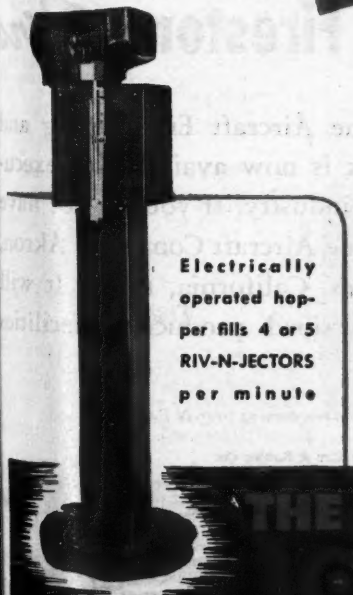
LICK YOUR RIVET SALVAGE PROBLEM

RIV-N-JECTORS are feather-light, easily handled

Riveting hand can be steadied while holding the RIV-N-JECTOR

with CLECO RIV-N-JECTORS

Three sizes: 1—for 1/16" and 3/32" rivets; 2—for 1/8" and some types of 3/32"; 3—for 5/32" rivets



Electrically operated hopper fills 4 or 5 RIV-N-JECTORS per minute

Question 1: What is the RIV-N-JECTOR? *Answer:* A magazine holding about 50 rivets, combined with a mechanism for releasing the rivets one at a time into the rivet holes.

Question 2: How much are rivet losses reduced with the RIV-N-JECTOR? *Answer:* Operator drops only 2 or 3 rivets out of 50, compared with a loss of over half when handled by hand—*a 90% saving!*

Question 3: How fast can riveting be done, using the RIV-N-JECTOR? *Answer:* Operators often insert and drive 30 rivets per minute.

Question 4: Do operators learn quickly? *Answer:* Almost at a glance; in a day they are 'Jector experts

Write for 16-page Bulletin 89

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The new Firestone Aircraft Engineering and Products Data Book is now available to executives of the aircraft industry. If you do not have a copy, write Firestone Aircraft Company, Akron, Ohio, or Los Angeles, California, today. It will show you the diversified production facilities available to you.

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AIRCRAFT COMPANY

SHIP BY AIR

plane Corp., is pamphlet issued by company giving transcript of Mr. Ward's testimony before House of Representatives. Select Committee on Postwar Military Policy . . . "Pax Aeronautica" by John W. Donaldson, deals with airpower, military and commercial, adapted to implement world commerce. Publisher is J. Henry Schroder Banking Corp., N. Y. C. . . . "Reconversion—The Job Ahead," analysis of reconversional problems by J. A. Livingston; and "Freedom of the Air", survey of postwar aviation problems, by Keith Hutchinson, are offered by Public Affairs Committee, N. Y. C. There is charge of 10c on latter two of these pamphlets.

Dow Corning Corp. announces new Silicone electrical-insulating synthetic resin made from sand, brine, coal, and oil. Tested by Westinghouse, Silicone-insulated motor reportedly gave over 300 percent increased power due to heat-resistance of insulation. Durability was demonstrated by 250 Kva generator, stated to be still in excellent shape after 3,000 hr. at high temperature of 428 deg. F.

A highlight, when Firestone recently exhibited its many war products in New York City, was self-catapulting autogiro built by G. & A. Aircraft, Firestone subsidiary. Several such models have been delivered to British on sample order. Top speed of craft is put at 118 mph. and hovering speed is 20 mph. Also displayed were wings for Curtiss C-46's, channel-tread plane tire nose wheels, plane seat cushions, bullet-sealing tanks, and distribution systems for anti-icing fluid.

Latest Curtiss-Wright war production drive promotional items emphasize theme that "It's a Long Way From Over."

Erratum: Inadvertently, the new word "flightstop" was misspelled "fightstop" in the boxed item appearing on page 214 of our July number. The editors trust that this error is not prophetic.

Word is released that the .50-cal. guns employed on Boeing B-29 "Superfortresses" are remotely controlled. The multiple-gun power turrets and computing devises for this gun-fire control are General Electric developments. In strategic, high-visibility firing positions, gunners merely operate small easily-swung electric sights, rather than the heavy guns as formerly. Fitted with double firing grips, sights automatically range the weapons which are mounted at some distance in turrets. High concentration of fire is enabled by use of this system.

Continental Air Lines' Denver modification center has been modifying B-29's since last February.

Obituary

Capt. Forrest E. O'Brine, who with Dale Jackson set a world record for endurance flight in Aug. 1930. He was senior service pilot in Ferrying Div. of ATC at time of his death.

Hollis R. Thompson, regional vice-president in charge of route development, American Airlines, and president of American Airlines de Mexico.

Frank A. Cooper, who served with Generals William Mitchell and Douglas MacArthur on the aviation committee of International Legion in Paris in 1927.

AMERICA AT WAR

Aviation's Communique No. 32.

Allied stategic aviation now blankets all of German occupied Europe. This was accomplished by engineers designing longer range into both fighters and bombers, and by establishment of air bases in Russia permitting triangular shuttle runs over the enemy, with the other two terminals in England and Italy. Other bases will be set up, and the present triangle will become a criss-cross pattern.

Tactical air support of the Allied invasion reduced losses to an impressive extent. Bombing and attack planes of AAF and RAF beat up enemy concentrations and transportation so badly that counter attacks were far weaker than expected. So depleted had the Luftwaffe become that it passed up the invading armada of ships.

Army's work of rehabilitation and new construction of airports is following closely as the enemy backs away in France and Italy. The time is approaching when Allied medium bombers and fighter planes can cover much of Germany, with bombs and heavy gunnery ranged on ground objectives. Fighters can carry up to 4,000 lb. of bombs, depending on the range. As the Luftwaffe weakens further, more and more Allied fighter planes will be free for direct attack on the enemy.

The Nazi's flying torpedoes are a hardship on England, but they will make little difference in the duration of the war. Flying missiles have been proposed for years, but the desperation of Germany brought the idea into practice. Probably it will become a major weapon in future. Accuracy of aim can be achieved electronically; or, in case of piloted-missiles, by airmen who would bail out close to the target.

Biggest attack on Nazi territory at this writing was a single-day smash of 3,000 heavies assembled by RAF and AAF, hitting Germany, France, and Italy, while thousands of tactical planes riddled transport and supplies in and around Normandy.

Allied bomber concentration was shifted from German aircraft plants enough to damage practically all of Hitler's oil production, which is variously reported to have been cut to 40 percent of capacity. Highest Army authority says the Reich's war machine is at last in a serious fuel shortage, and that the payoff has begun to show up in several other important deficiencies in enemy supplies and equipment.

In the Pacific, occupation by the Navy of Saipan and other bases in the Marianas brings into our line of fire the Jap-occupied Philippines, much of the Netherlands, and Japan itself. By the much-condemned island-hopping route, American and British forces have arrived at the main battleground.

The Jap Navy, vastly outweighed by Allied forces, is still wisely backing water, but the time draws near when it must stand to and slug. Navy Secretary Forrestal explains that the Marianas naval encounter, in which the Japs lost 30 ships sunk and damaged and 141 planes, was not a show-down; the enemy simply retired.

Forrestal says that the United States Navy has added 100 carriers, 30,000 planes, and eight battleships to its striking power since July, 1940. Rear Adm. Arthur W. Radford, acting deputy chief of air operations, reveals that 22 regular fleet carriers have been commissioned since Pearl Harbor. Quick creation of the great carrier force now in action is generally regarded as one of the outstanding industrial achievements of modern times. In equal combat, equal distances from home base, Jap sea forces would be puny by comparison.

Navy reveals that its own and Marine Corps flyers have destroyed 6,259 Jap planes in the air and on the ground since the infamous Dec. 7. This compares with American losses of 1,277. Biggest of all Jap aircraft losses in a single engagement was at the Marianas in latter June, total 353, against Allied losses of 21. Biggest previous Jap airplane loss was 275 at the battle of Midway.

Even more intriguing to news readers than these powerful blows at sea are the B-29 attacks on Japan proper, in which the enemy gets paid back, dramatically, for Pearl Harbor. As the Japs very well know, it is not lack of *Superfortresses* but lack of gasoline to fly them, on which Nippon is borrowing time. The Navy does not say whether enough fuel ever can be flown into China for the B-29's and other AAF operations there, or whether the main attack must wait upon a beachhead and break-through in China. B-29 operations at first are conservative, but maximum range will be used as command and crews get used to their equipment.

Establishment of the 20th Air Force, commanded directly by Gen. Arnold, and its implementation with *Superfortresses,* is perhaps the most significant military development in this war, so far. Any nation possessing such long-range air power can strike with bombs and guns and troops, any place in the world. Any country can be invaded, bombed, and shot up within two days after some militarist makes up his mind to that end. It remains to be seen whether and how this new force can be used to keep the peace.

STUDY FUTURE AIR CARGOES

Plans for reciprocal sky movement of perishables and manufactured goods were recently discussed in Washington by Assistant Sec. of Commerce William A. Burden (left), Col. Edward S. Evans (center), Detroit industrialist and loading expert, and Sec. of Agriculture Claude R. Wickard (right). The colonel's recently formed project, Evans Transportation Research, headquarters in the Capital, is working in collaboration with the Depts. of Agriculture and Commerce in these studies. (Press Association photo.)

★ CANADIAN NOTES ★

By James Montagnes

Production costs in Canadian aircraft plants have been cut by $534,359 through adoption of ideas of workers for speeding up jobs or doing them at less expense. Workers have received a total of $64,096 in awards. A merit awards for the best 25 ideas of the year will be given out in September by Ralph P. Bell, director-general of aircraft production for Canada.

Trans-Canada Air Lines is increasing the number of war-veteran pilots on its runs in Canada. By end of June, 18 pilots who had completed operational duties overseas, were flying with senior pilots of TCA after completing a special

How many hands does a turret lathe operator need?

— only two — if it's a Jones & Lamson

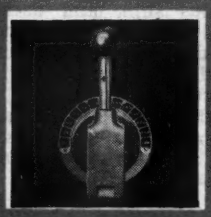
Many a turret lathe operator must have wished, at times, that he were like the six-armed deity of the Hindus, for faster-cutting tools have greatly increased the productivity of these machines and the burden upon the operator. The necessity for simplified controls to save waste motion and operator fatigue is, therefore, imperative!

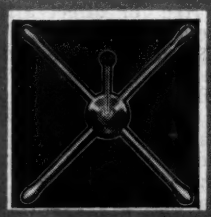
Jones & Lamson Universal Turret Lathes are designed not only to take full advantage of the fastest-cutting tools, but also to give every mechanical aid to the operator so that he can operate to the maximum capacity of the machine without undue fatigue.

We show here some of the man-saving, time-saving features built into these machines. Write to us for more detailed information and descriptive literature.

SINGLE LEVER SPINDLE SPEED SELECTOR

With direct reading dial, to control all spindle speeds. Next speed pre-selected while cut is in progress.



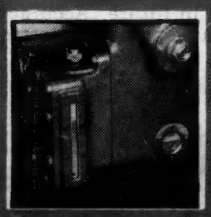


POWER TRAVERSE AND INDEXING OF THE HEXAGON TURRET

Turret of saddle type machines is power traversed and power indexed. A time saver and man saver too.

SINGLE LEVER FEED SELECTORS

Controlled by single lever, direct reading, selectors. Feeds pre-selected while cut is in progress.

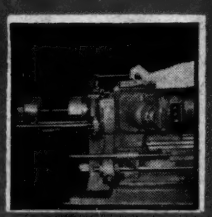


AUTOMATIC LUBRICATION SYSTEM

Requires minimum of attention. Flow of lubricant automatically increases as spindle speed increases.

AUTOMATIC COOLANT SUPPLY TO HEXAGON TURRET

A copious supply of coolant is pumped automatically to the working face of the hexagon turret.



SIMPLIFIED BAR FEED AND COLLET OPERATING MECHANISM

Operated by a single lever, which opens chuck, feeds in stock and closes chuck.

All these features and many others are incorporated as standard in Jones & Lamson Universal Turret Lathes.

JONES & LAMSON
MACHINE COMPANY
Springfield, Vermont, U.S.A.

Manufacturers of: Universal Turret Lathes • Fay Automatic Lathes • Automatic Double-End Milling and Centering Machines • Automatic Thread Grinders • Optical Comparators • Automatic Opening Threading Dies and Chasers.

navigational course to acquaint them with airline procedure.

Canada has sold a number of training aircraft to Mexico—planes no longer useful in the air training plan.

The Fort William, Ont., aircraft plant of Canadian Car & Foundry Co. will be kept in continuous production during 1945. This plant, currently making Curtiss "Helldivers" for U. S. Navy, employs nearly 8,000 workers.

Some 28 RCAF training schools are being closed this year, and eventually these will be turned over to War Assets Corporation, the government company established to realize on wartime equipment. It is expected that these centers will be placed under the Department of Transport for later use in the development of civil aviation in Canada. RCAF has almost 12,000 training aircraft, more than 5,000 being single-engined and nearly 6,000 being twin-engined.

Canada's policy for divorcing air and surface transport companies after the European war has a possible loophole. This was learned when amendments for the Aeronautics Act came up in House of Commons recently. One amendment provides that no license for commercial air service shall be issued to any person "engaged in the transport of goods or passengers for hire or reward by means other than aircraft unless the Government-in-Council is of opinion that it is in the public interest that such a license be issued." Thus a decision claiming public interest might curb the government-announced policy that Canadian Pacific Air Lines must be broken up into its previous component companies, and divorced from ownership by Canadian Pacific Railway. Amendments to the Aeronautics Act also call for establishment of a three man Air Transport Board, appointed for periods of 10 yr.

By F. H. Fullerton

It is reported that Boeing Aircraft of Canada, Vancouver, has now delivered $25,000,000 in planes and other equipment.

The subassembly plant operated since last fall by Powell River Co., Powell River, B. C., is scheduled to close down in November when present contract on airplane parts for Boeing will be completed.

★ CALLING NAMES ★

James L. Kinney has been appointed chief of Air Carrier Division, Washington, D. C.

Alfredo de los Rios, founder of Inter-American Escadrille, joins Fairchild Engine & Airplane Corp. as assistant to director of foreign relations, and **Allen W. Harris,** former aviation editor of Baltimore *Sun,* joins public relations staff.

United Air Lines staff appointments: New district traffic managers are: **Kenneth M. Bates,** Toledo, **Sterling W. Nelson,** Hartford, and **Herbert E. Ruprecht,** Philadelphia, acting manager. **Harrel Gladish** is appointed supervisor of payroll accounting, Chicago. Meanwhile, UAL announces system-wide analysis of ticket counter expansion by **Maurice L. Perry,** superintendent of counter operations. **R. F. Ahrens,** director of personnel for UAL, has been elected chairman of the personnel committee of the Air Transport Association. **Gilbert K. Brower,** chief materials engineer for AA, has been appointed vice-chairman of the Coordinating Lubricants Research Committee, division Coordinating Research Council, sponsored by American Petroleum Institute and SAE.

Consolidated Vultee makes these appointments. At Fort Worth Div., **Verser C. Gillon** as production superintendent and **James A. Healy** as assistant chief of contracts. At Allentown Div., **Nelson Metcalf** as chief industrial engineer, **J. M. Langseth** as superintendent of detailed fabrication, **E. F. Mussen** as general foreman, bench assembly, and **Howard M. Kincheloe** as chief of flight and field operations. **C. J. Duisen,** supervisor of receiving dept., Tucson, becomes superviser of receiving and stores at New Orleans Div.

Pan American Airways has awarded 15-yr. pins to **Capt. Arthur LaPorte,** chief flight officer of PAA's trans-Atlantic operations; **Cleason E. Shealer,** shop superintendent of Atlantic Div.; **Edward W. McVitty,** asst. div. manager of Atlantic Div.; and **Fred Dawson,** communications supervisor at trans-Atlantic headquarters.

Walter Sternberg has been made general traffic manager of EAL.

Realignment of duties and promotions within the engineering activities of sales dept. of Pratt & Whitney involves new titles as follows: **Louis H. Gitzinger** becomes chief installation engineer; **Norman F. Larson** is named assistant chief installation engineer; **John M. Tyler** is appointed installation consulting engineer; **A. L. MacClain** becomes liaison engineer, with **N. J. denTex** as installation requirements engineer; **O. C. Christianson** is named engine performance engineer; **D. S. Conrad** becomes airplane performance engineer; **Reynold L. Caleen** becomes chief of performance and installation requirements; **C. J. Swigert** is appointed chief of installation test operations, with **V. E. Thornburg** as installation analysis engineer and **John B. Cutting** as operating instructions engineer.

Charles Hummel, comptroller of Bendix Aviation Corp., Detroit, and **Clayton A. Hinds,** comptroller at Teterboro, N. J., plant, have been elected to membership in the Comptroller's Institute of America.

Howard Field has been retained as consulting engineer by Aeroquip Corp., Jackson, Mich.

J. C. Brawner, formerly with Economic Bureau of the CAB, was named as assistant to the pres. of National Airlines, Jacksonville, Fla.

SAE announces appointment of **George H. Compter** as staff engineer in Aero Div.

Lt. Col. Robert F. Six, who has been on leave from his duties as pres. of Continental Air Lines, has returned to his executive position.

THE WASHINGTON WINDSOCK

By BLAINE STUBBLEFIELD

The 20th Air Force suggests the first practical, sufficiently mobile implementation for any international police power that might be formed. With B-29's and future long-range supercraft, world cops could answer calls anywhere in the world in 48 hr., with heavy bombardment, aerial gunnery, and parachute ground forces.

As the Allies gain air bases closer to Germany, swarms of medium bombers, fighters, and other attack planes can reach the enemy, loaded with bombs and/or ammunition. Weakening Luftwaffe will permit increasing numbers of them to switch from convoy duty to direct attack.

The two initial B-29 attacks on Japan were conservative. Planes have returned with large quantities of fuel. Much of Nippon is in reach from present bases. There are plenty of B-29's, but there hasn't been enough gasoline transportation to China. That bottleneck is being busted.

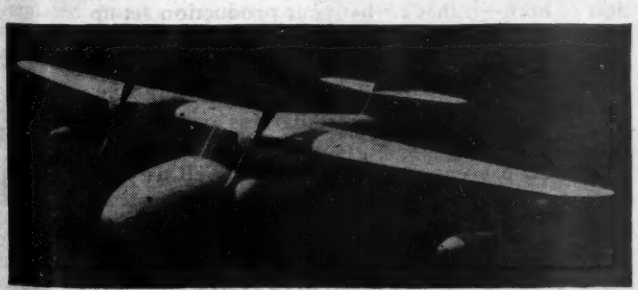
Navy reveals that not a single ship-based gun was fired in the battle of Wake Island.

Remember when the press, public, and Congress were demanding transport planes to fly war supplies over the sub-infested Atlantic? Navy came within a cat's whisker of getting a directive to give such airplanes priority far above everything else. It might have put war progress far behind where it is now.

Navy Secretary Forrestal is not opposed to unification of land, sea, and air forces under one war office. But he, too, says this is not the time to do it.

The administration of aviation in Washington is in good shape. Charles Wilson and Donald Nelson of WPB, Ted Wright of Aircraft Resources Control Office, Gen. Arnold and Adm. Ramsey and several staff members of the air arms, Col. Edgar S. Gorrell of the Air Transport Association, and the Civil Aeronautics Board—all deserve citation with a riffle of drums.

The payoff for Allied strategic air attack on Europe is showing up clearly now, according to an off-the-record statement by an officer in the highest command. He says the Germans, in addition to suffering from curtailed aircraft production, are now in a serious oil shortage, and several other kinds of supply and equipment are inadequate to their task.

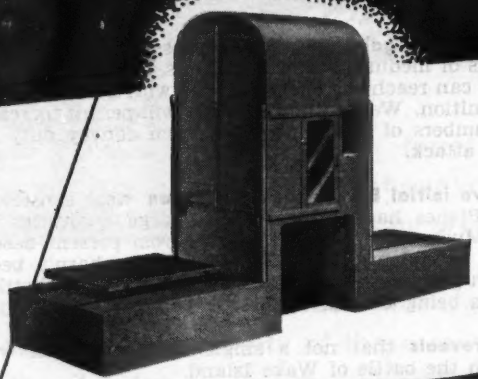


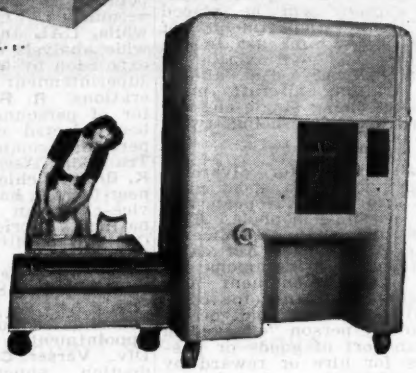
INTRODUCING "TRIMMER" AMPHIB

Preview of Allied Aviation's "Trimmer" (named for designer, Gilbert Trimmer). It is three-seat twin-engine light amphibian, built almost exclusively of plastic bonded plywood. Designed for private flyers and base operators, plane has detachable center section incorporating engines, instruments, throttles, switches, battery, flaps, and flap controls. Entrance hatch is just back of wing and another is in nose. Tires of retracted wheels extend beyond fairing and act as buffers against mooring docks and boats. Landing gear is detachable for use of craft solely as seaplane to provide for carrying fuel tanks in wheel recesses. Company officials estimate present plant could turn out 100 a month.

KELEKET X-RAY CAN IMPROVE YOUR PRODUCT

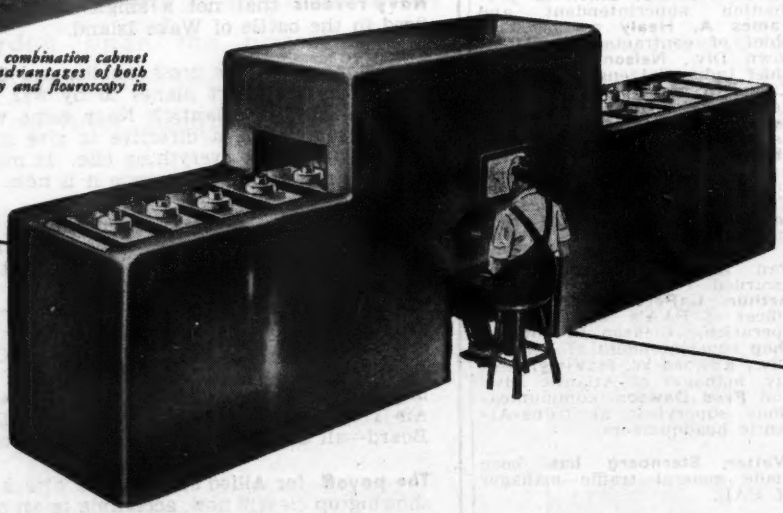
KELEKET *radiographic cabinet used for inspecting critical airplane parts.*





KELEKET's *mobile inspection cabinet operates fluoroscopically or radiographically.*

KELFKET *combination cabinet provides advantages of both radiography and flouroscopy in one unit.*



KELEKET's *conveyor belt fluoroscopic cabinet for high-speed, continuous inspection, may also be used radiographically.*

There is no question about X-ray's performance in industry today—nor the job it can do on the product you make.

Castings? Welds? Complete assemblies? Only X-ray inspection can detect every defect speedily, inexpensively, non-destructively, and before costly machining operations are performed. Marvel of industrial efficiency, no modern plant will do without it.

KELEKET—the quality name in X-ray—knows industrial inspection through and through. KELEKET knows above all that X-ray equipment must fit your plant. That's why KELEKET incorporates X-ray into cabinets—fluoroscopic, radiographic, or a combination of both—if that's what your production set-up requires. That's why KELEKET cabinets are stationary or mobile—or even conveyor units that become an integral part of a moving assembly line.

Hundreds of KELEKET installations in plants all over the country are improving products, cutting costs, and preventing failures in use. Tell us your problem, show us your plant, and we'll demonstrate how X-ray can serve you best.

KELEKET representatives are located in 64 cities in the U. S. and Canada—consult the one nearest you or write direct to Covington for complete information.

PIONEER CREATORS OF QUALITY X-RAY EQUIPMENT SINCE 1900

KELLEY-KOETT X-RAY MFG. COMPANY

2408 WEST FOURTH ST., COVINGTON, KY.

Big Bomber Production Up; Weight Output Static in June, Unit Total Down to 8,049

NACA forms materials research committee . . . Surplus warplane plan offered by Harvard . . . See action in war-peace transition moves . . . Brewster plant to Navy . . . AWPC East reports veteran-hiring plan.

Production figures for June disclose that total airframe weight maintained an even level, while unit output declined to 8,049, a drop of 9 percent from the May figure of 8,902. However, output of four-engined bombers was ahead of schedule.

Greatest decrease was in trainer types; production of Curtiss C-46 cargo planes dropped 63 units from the May total, and Navy fighter deliveries were off. Plants producing the Boeing B-29 "Superfortress" were on schedule, one was ahead of it. The new Douglas plant at Chicago outran its quota 15 percent on Douglas C-54 cargo planes.

The loss of trainer output probably can be made up, as also can the loss of Navy fighters, in the opinion of Charles Wilson, chairman of the Aircraft Production Board. He doubted if the C-46 schedule could be overtaken. Still, Mr. Wilson indicated the losses are not serious. Navy is getting plenty of fighters, and trainer procurement is no longer a problem.

Airplane requirements shown in the Army's budget estimates for fiscal 1945 are much lower in number of units and somewhat lower in weight than in fiscal 1944. But Gen. Arnold, AAF chief, testifying before a Congressional appropriations committee, said that 1944 production would carry over into 1945 and that no poundage reduction is contemplated. Enemy weakness or capitulation could, of course, cause the schedule to be cut deeply at any time.

NACA Forms Materials Research Committee

A committee on materials research coordination has been formed by the National Advisory Committee for Aeronautics to: (1) Collect, analyze, and distribute information on aircraft materials; (2) maintain and distribute a list of current projects; (3) receive information on specific investigations and suggest new projects, outline their scope, and recommend places where the work can be done; and (4) administer distribution of aircraft materials research.

The materials committee was activated upon request of Maj. Gen. Echols, assistant staff chief of AAF, and Rear Adm. Ramsey, chief of the Navy Bureau of Aeronautics. Membership of the committee: NACA, AAF, Navy Bureau of Aeronautics, CAA, WPB, Office of Scientific Research & Development, and the National Research Council. Later, representatives of the aircraft industry, aircraft war production councils, and other research organizations will be invited to join and assist the committee in its investigations.

See Action in War-Peace Transition Moves

After more than a year of discussion, Congress and the Administration seem about to take action on a war-peace transition measures.

A Senate-House conference committee finally agreed on the Contract Termination Bill, which will have been passed when this writing appears; the Senate started work on the Clayton Bill, which will control the disposal of military surplusses, including airplanes; Senate began redrafting the Kilgore Bill, which provides for demobilization of manpower. Congress convened Aug. 1; observers expected that transition legislation would be completed this fall. Sudden end of the German war would catch the government unprepared for tremendous cessation of war production.

Meanwhile, the Joint Contract Termination Board issues a uniform contract termination formula for fixed price subcontracts, supplementing the prime contracts formula.

Mr. Roosevelt reported to Congress his recommendations on surplus property disposal, revealing that AAF has set up at Wright Field an inventory system which reveals, on any given day, the total production equipment and aircraft for which AAF is accountable.

Surplus Warplane Plan Offered by Harvard

Engaged by Army Air Forces to study disposal of surplus warplanes, Harvard School of Business, recommends that surplus transport types be sold to the airlines on installment contracts, subject to termination, instead of being sold outright or leased.

HSB also recommends that sale price be based on commercial value rather than on cost to the government; that government pay overhaul costs; and that purchaser pay for conversion in cases where planes are to be used for passenger service.

In the interest of safety, combat planes should not be sold to civilians, the report states.

Chamber Divisions Defined

Under the reorganization by John Lee, the Aeronautical Chamber of Commerce now consists of two main operating groups: The Aircraft Manufacturers Council and the Personal Aircraft Council. The Economic Development Department and its functions, together with those of the technical department, traffic department, industrial research and statistics, legislative, and information and public relations, are incorporated in the Service Bureau. Chamber headquarters in Washington are now open from 8:30 a. m. to 8:00 p. m. daily, except Saturdays when offices close at 6:00 p. m.

Brewster Plant to Navy

The elaborate Johnsville, Pa., plant of Brewster Aeronautical Corp. has been taken over by the Navy as a modification and engineering center to be operated in conjunction with the Navy Air Material Center at Philadelphia. Navy absorbed about 2,500 of the plant's 3,500 employees, and most of the balance have been transferred to other employers. After several changes of management since the war production boom began, and after Congressional charges of inefficiency, Brewster's contract for Navy "Corsair" shipboard fighters was canceled as of July 1. Previously the company had lost its contract for SB2A dive bombers.

War Weapons for Peace

New Joint Research Committee of the Army, Navy, and government civilian agencies, for continuous development of war weapons in peacetime, covers the entire military field —except aeronautics, which continue with the NACA. When the new committee has reached initial conclusions it will submit them to the Woodrum Postwar Military Policy Committee in Congress, which will determine the nature and extent of peacetime military establishments.

AWPC East Announces Veteran-Hiring Plan

Broad policy to giving employment preferences to discharged war veterans is announced by the Aircraft War Production Council, East Coast, in a recent general report. Brought out was the fact that some 15,000 veterans of this war have already either been newly hired or rehired by the member companies (Aviation Corp., Bell, Chance Vought, Curtiss-Wright, Eastern, Fairchild, Martin, and Republic).

Each member firm has taken special steps for handling veterans' applications. From company to company, these procedures vary, some being

POWER BEHIND CATAPULT TAKEOFFS

Testing shell in breech mechanism of new plane-launching catapult gun at U. S. Naval Ordinance Westinghouse-operated Plant, Canton, Ohio. Expanding gases from shell send piston-driven cart along catapult track to launch scout planes from battleship and cruiser decks.

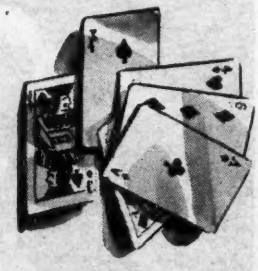
FOR YOUR POSTWAR PRODUCTS... THE MOST *Versatile* FINISH OF ALL

METAL. Nitrocellulose lacquer offers big advantages to manufacturers using metal: *Unlimited* color range—high gloss or dull matt finish—*fastest-drying* finish known—easy and cheap to apply and repair.

LEATHER. Lacquered leather lasts longer—looks lovelier, because it is protected from perspiration, scratches. May be easily cleaned.

RUBBER. Nitrocellulose lacquer is an extremely flexible finish—making it ideal for galoshes, many other rubber articles. Imparts gloss and preserves the rubber.

WOOD. Good for both expensive *and* economy types of furniture, nitrocellulose lacquer protects, lasts, looks well, resists dust and fingerprints, ideal for assembly line production.



PAPER. Paper may be *rollercoated* with crystal-clear or colored nitrocellulose lacquer. Brightens and intensifies colors, resists scuffing, damage from handling, fats, acids and fingerprints. Waterproofs, is washable.

FABRICS. There's a growing market for light, airplane-type luggage—and nitrocellulose lacquers are the ideal finish—non-scaling, never sticky, good-looking.

CL-46

HERCULES

NITROCELLULOS

Hercules makes no finished lacquers, but supplies the nitrocellulose from which lacquers m
For helpful application information on your finishing problem, call your lacquer suppli
lose Products Department, Hercules Powder Company, 963 Market Street, Wilmington, D

notably well developed. It is pointed out that, due to the influence of many factors, jobs cannot be guaranteed; however, insofar as possible veterans will be given first call.

★ ASSEMBLY LINES ★

Douglas Aircraft Co. has issued plans calling for 600 percent expansion of parent plant's C-54 "Skymaster" program. Delivery of 5,000th A-20 was revealed.

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FOR YOUR POSTWAR PRODUCTS...

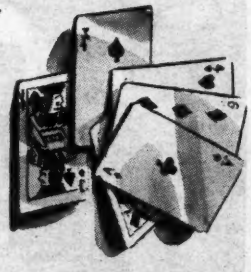
THE MOST *Versatile* FINISH OF ALL

METAL. Nitrocellulose lacquer offers big advantages to manufacturers using metal: *Unlimited* color range—high gloss or dull matt finish—*fastest-drying* finish known—easy and cheap to apply and repair.

LEATHER. Lacquered leather lasts longer—looks lovelier, because it is protected from perspiration, scratches. May be easily cleaned.

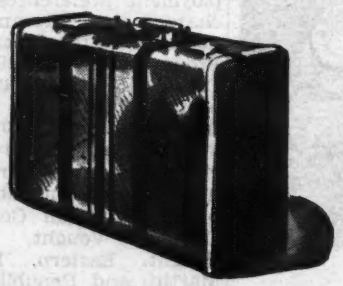
WOOD. Good for both expensive *and* economy types of furniture, nitrocellulose lacquer protects, lasts, looks well, resists dust and fingerprints, ideal for assembly line production.

RUBBER. Nitrocellulose lacquer is an extremely flexible finish—making it ideal for galoshes, many other rubber articles. Imparts gloss and preserves the rubber.



PAPER. Paper may be *rollercoated* with crystal-clear or colored nitrocellulose lacquer. Brightens and intensifies colors, resists scuffing, damage from handling, fats, acids and fingerprints. Waterproofs, is washable.

FABRICS. There's a growing market for light, airplane-type luggage—and nitrocellulose lacquers are the ideal finish—non-scaling, never sticky, good-looking.



CL-46

HERCULES

NITROCELLULOS

Hercules makes no finished lacquers, but supplies the nitrocellulose from which lacquers are m
For helpful application information on your finishing problem, call your lacquer supplie
lose Products Department, Hercules Powder Company, 963 Market Street, Wilmington, Del

notably well developed. It is pointed out that, due to the influence of many factors, jobs cannot be guaranteed; however, insofar as possible veterans will be given first call.

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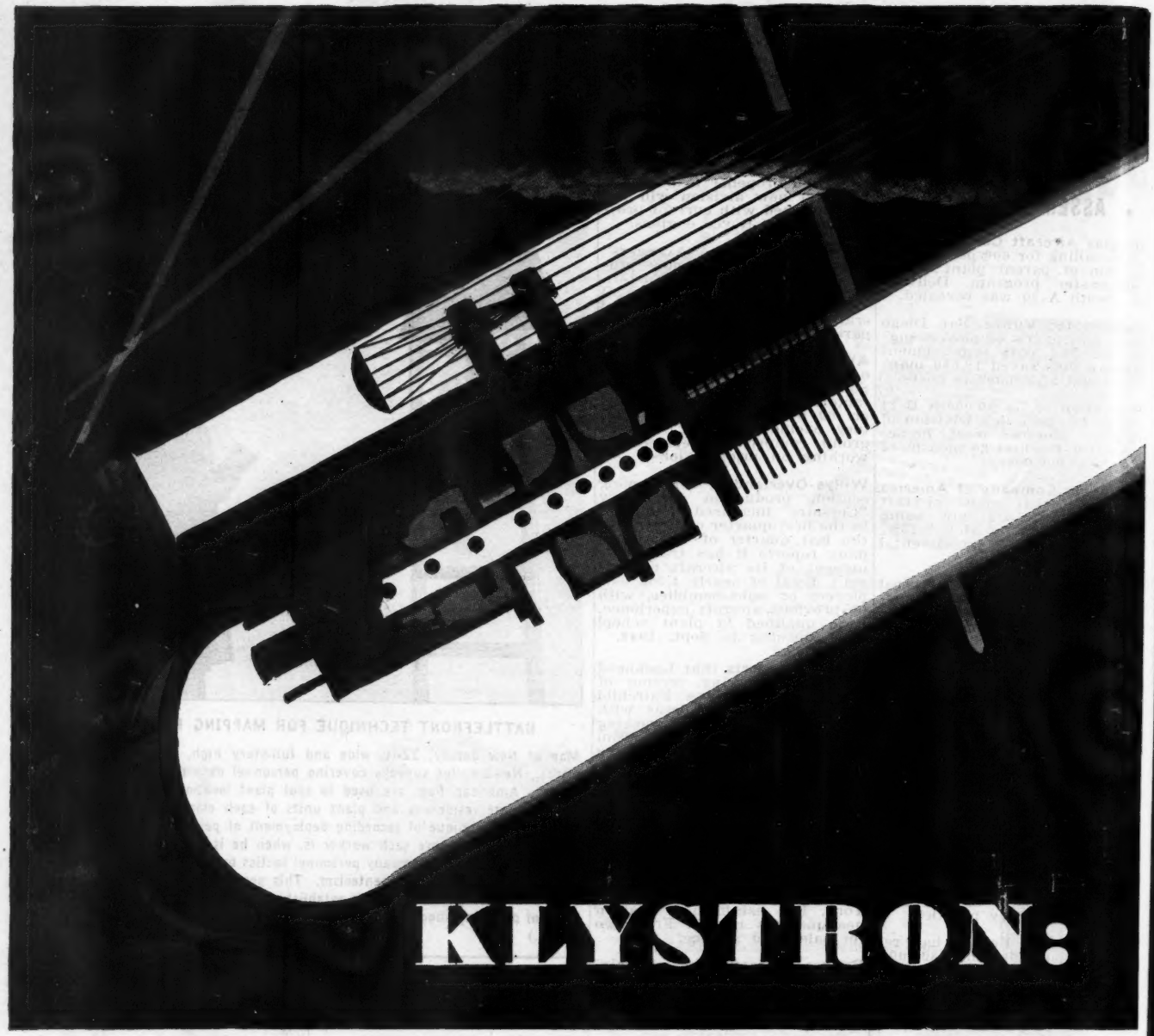


KLYSTRON:

A pencil of energy beamed like light

IF YOU'LL imagine an *invisible* searchlight beam, you'll have a good picture of how Klystron-generated radio waves can be directed into a narrow "pencil" of energy.

▶ This direction is accomplished by suitable reflectors. The beam of ultra-high-frequency waves travels in a straight line, and it can pierce fog, smoke, and clouds which would stop a light beam.

Sperry-developed Klystron tubes are used in many equipments now serving our Armed Forces. Later, *Klystronics* will open the door to the development of many ingenious peacetime devices.

▶ **Klystrons are now being produced in quantities, and certain types are available.**

The name "KLYSTRON" is a registered trade-mark of the Sperry Gyroscope Company, Inc. Like many other Sperry devices, Klystrons are also being made during the emergency by other companies.

Sperry Gyroscope Company INC.

GREAT NECK, N. Y. • DIVISION OF THE SPERRY CORPORATION

GYROSCOPICS • ELECTRONICS • AUTOMATIC COMPUTATION • SERVO-MECHANISMS

Begin CAB Conferences on World Air Routes; Consider Atlantic Runs First; Hearings Later

U. S. Chamber proposes role by surface transport . . . Return more DC-3's . . . Airmail bottleneck eased . . . Feeder group names officers . . . TWA asks global routes.

American flag foreign airline routes desirable for postwar installation having now been charted on a world map by the Civil Aeronautics Board, next in order are pre-hearings on about 100 route applications on file, and on amendments and applications that will be filed.

CAB has divided the proposed U. S. world airline system in five regions, with conferences and hearings scheduled as follows:

Area	*Conference*	*Hearing*
N. Atlantic....	Aug. 1	Oct. 16
S. Atlantic.....	Aug. 2	Nov. 1
N. Pacific.....	Sept. 1	Dec. 13
Cent. Pacific...	Sept. 15	Jan. 10
Australia	Oct. 2	Feb. 1

Questions of what applications will be consolidated with which groups is being decided at these conferences.

All government agencies, including the President and the State Department, and major Allied governments were consulted during the year-long preparation of the Board's proposals—and all are said to have given approval to the "blueprint."

The proposed U. S.-foreign air system is the first conclusive move in the long and intricate process of international agreement on the division of air commerce. This country's foreign lines, of course, will be only part of the total world airline picture. On t p of it must be imposed the air systems of Britain, Russia, China, France, Netherlands, Italy, and others. All authoritative opinion thus far is that Germany and Japan will not be allowed to operate beyond their own borders.

The system is intended to take care of the air traffic needs of this country, and allowances were made for traffic to be carried by other national services. Rights of entry by our lines into other countries, and their lines into this country, will continue to be negotiated on a reciprocal basis. But because the U. S. originates more air business than other countries, trading will be schedule - for - schedule, not route-for-route.

Questions left untouched in the Board's proposal are: Freedom of the air over foreign sovereignties; fuel and service stops on foreign soil; "sabotage" (movement of goods and persons by the air and ship lines of one country between two points in another country); use and ownership of airbases built during the war (mostly by the United States) on the soil of another country (mostly the British Empire).

U. S. Chamber Proposes Surface Transport Role

Controversy over the right of surfaces transportation to establish air auxiliary services, quieted when the Lea air transport bill was tabled by the House of Representatives Rules Committee, has been raised again in another place —the Chamber of Commerce of the United States. CCUS Board of Directors proposed that operators of one form of transport tion be permitted to operate other forms within "reasonable" territorial limits, or that operators of different forms be encouraged, under legal safeguards of the public interest, to coordinate their services through contractual arrangements. The Chamber then began to poll its 1900 member organizations for opinions on the proposals.

Col. Edgar S. Gorrell, president of the Air Transport Association, wrote all Chamber members, detailing his contention that a policy of "integration", partial or total, would "lead to domination of all types of carriers by a few super-monopolies of transportation."

More DC-3's Returned

War Department in late June returned still more DC-3 planes to the air-lines—another 15—bringing the total in civil operation to 257 as compared with 324 in May, 1942. United received six, American five, and Northwest, Eastern, Braniff, and Penn-Central one each. CAB made the allocations. Opinion in Washington is that the airlines may have all of their planes back by the year-end, perhaps a few DC-4's also, then or early in 1945.

Airmail Bottleneck Eased

After a winter of serious airmail delays, sometimes impeding the war effort, about 80 percent of all airmail is now moving direct to its destination. This improvement is due to: Return of many requisitioned airplanes to the airlines; increased utilization of equipment, enabling the lines to operate 26 daily transcontinental trips (highest on record according to C. P. Graddick, United Air Lines director of cargo); relaxation by the Army of its civil airline space requirements (upon urgent request of the Post Office Department, which had not set up an airmail priorities system).

Feeder Association Elects

In its first permanent-organizational meeting in Washington, Feeder Airlines Association named Harry R. Stringer, vice-president of All American Aviation, Wilmington, Del., as Association president. Other officers: Vice president, William R. Kent, president of Southair; Treasurer, Joseph J. Mitchener, general manager of Hawthorne Airways; Secretary, Bowman R. Otto, president of Otto Aviation Corp. Intention of Association is to extend to the maximum number of persons the benefits of direct air services.

As we went to press, the latest Washington word regarding feeder lines was a CAB statement that it seemed advisable to initially restrict feeder and pickup air service authorizations to temporary periods, perhaps three years, in order that national short-hop economics may be shaped most satisfactorily.

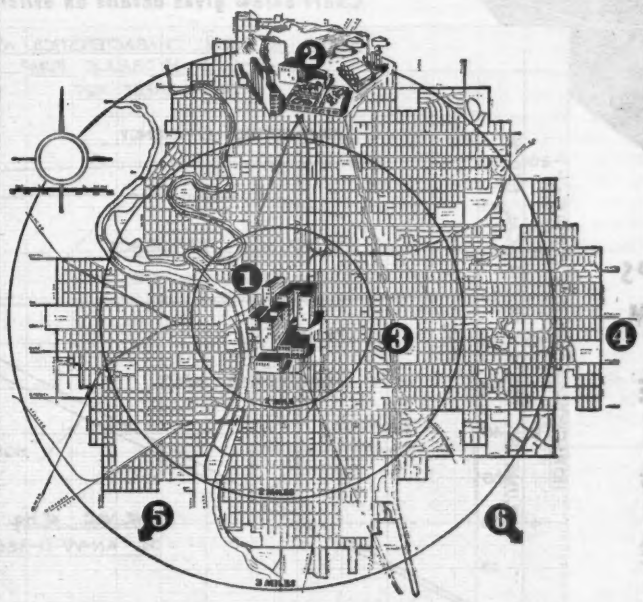
TWA Asks Global Routes

Transcontinental & Western Air has made application for the most elaborate air route setup on record so far. TWA wants to add 20,000 mi. to its present system, extending its service clear around the world, and putting any point on the system within 38 hr. of the United States. From Seattle and San Francisco, the TWA world circle would touch Chicago, Detroit, Washington, New York, Boston, Presque Isle, Maine, then follow the north Atlantic route to London, Berlin, Vienna, Budapest, Athens, Cairo, Bagdad, Calcutta, Chungking, Tokyo, Attu, Alaska, with many intermediate stops.

Applications and Grants

Recent airline applications and grants are reported as follows:

Hawaiian Airlines has filed application with the CAB for passenger, freight, and mail routes in the central and western Pacific.



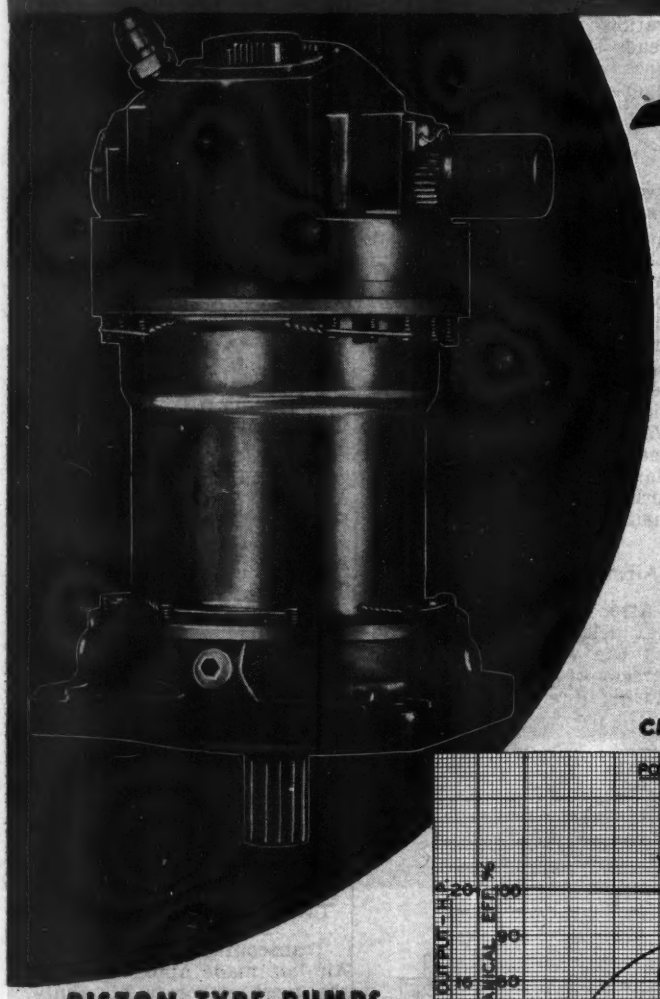
WICHITA'S PLAN FOR AIRPARKS

Map illustrates Wichita's airpark plan, which places emphasis on development of facilities for private owners. At (1) is proposed site of airpark within walking distance of business district; site (2) would serve city's stock yards, oil refineries, and other plants; (3) and (4) would be residential-district airparks for private plane owners; and (5) is proposed additional field to supplement city's municipal airport indicated at (6). Airpark plan, now being promoted through Aero Chamber's Personal Aircraft Council, is blueprinted in pamphlet "Airparks, Flightstops, and Air Harbors for Airminded Communities," by Joseph T. Geuting, Jr., Council chairman and v.-p. of General Aircraft Corp.

PRECISION BUILT

New LEUBRO HYDRAULIC VARIABLE VOLUME PUMP

FEATURES



Long Life

The new LEUBRO Pump was engineered to include a combination of long desired features to answer an urgent demand of the aircraft industry.

The LEUBRO Pump meets the overall requirements of all systems up to 3000 lbs.—delivers 7 g. p. m. at 3500 r. p. m. It performs with minimum heat rise—is self-lubricated—withstands torsional vibration—is extremely quiet in operation at all pressures. Positive type, all-metal oil seal prevents oil leakage during the entire life of pump.

The new LEUBRO Pump will take the terrific strain and constant pounding of a 3000-lb. system, even though light enough in weight that it can be used from both an efficiency and weight standpoint on any system.

The LEUBRO Variable Volume Pump, which completely eliminates the unloading circuit, also has adjustable cut-out pressure and adjustable pressure differential. These features have never before been incorporated in a pump.

Complete information and engineering service available.

Chart below gives details on efficient LEUBRO Pump performance.

PISTON TYPE PUMPS
7 G.P.M. at 3500 R.P.M.

●

VARIABLE VOLUME
Compact 6⅞" long
Lightweight, 9 pounds

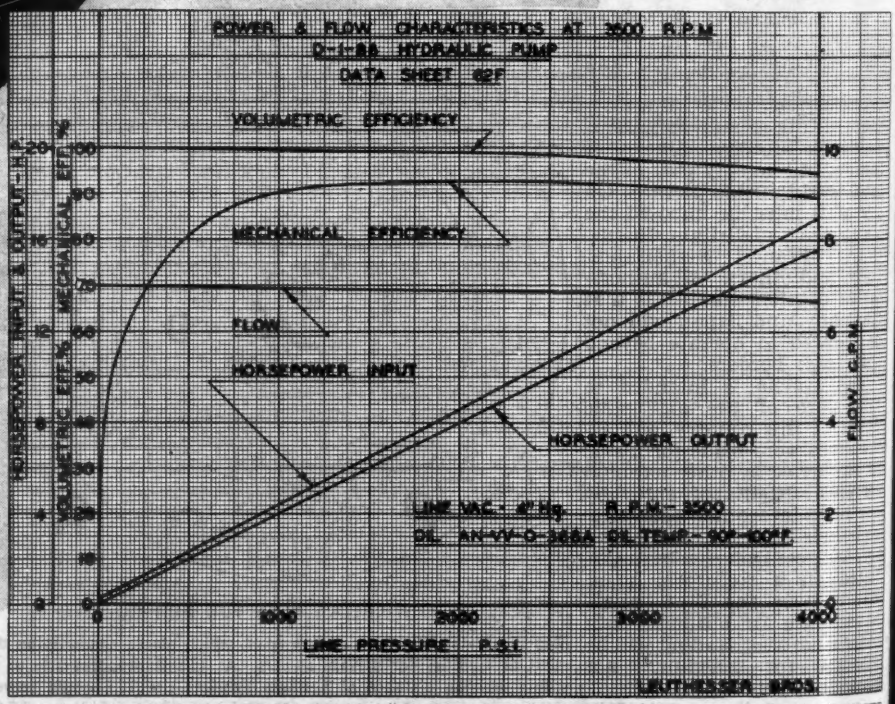
●

CONSTANT VOLUME
5 15/16" Long, 8 pounds

●

All parts are interchangeable

●



LEUTHESSER BROTHERS
21 NORTH LOOMIS STREET • CHICAGO 7, ILLINOIS

Routes requested are: (1) Honolulu and Shanghai via Midway and Tokyo; (2) Honolulu and Manila via (a) Wake and Saipan in the Marianas and (b) Johnston, the Marshall Islands, Ponape, Truk, and Palau. Applications for extentions were: UAL's request to make Cedar Rapids, Iowa, an intermediate stop between Moline and Des Moines on the United coast-to-coast run . . . National Airlines' request to inaugurate service in and out of Palm Beach on the Jacksonville-New York run . . . AA's request to extend transcontinental route from Los Angeles to San Francisco-Oakland and permission to extend Chicago-Dallas route to include Huston, Tex. . . . Application has also been filed for provision of additional airmail and passenger service for key points in intermountain states. Requested by John M. Lewis of Denver, Colo., proposed service would include Salt Lake City, Provo, Price, and Green River in Utah; Denver, Colo.; Cheyenne, Wyo.; Albuquerqua, N. Mex.; and intermediate points. Hearing on this application is set for Sept. 5.

CAB has approved following applications: EAL to operate between New York city and St. Louis . . . Braniff to include Topeka, Kan., as additional stop . . . Continental Airlines to include Hutchinson, Kan., on Denver-Salina run . . . Northeast Airlines to operate between Boston and the intermediate points of Worcester, Waterbury, New Bedford, and Fall River, Mass., and the co-terminal New York and Newark . . . UAL to operate between Cleveland and Boston, With Hartford as Intermediate point . . . TWA to operate between Pittsburgh, Williamsport, Pa., Binghamton and Albany, N. Y., and Boston . . . EAL to designate Boston as a terminal on flights originating or terminating South of Richmond, Va., or west of Charleston, W. Va.

New Wisconsin Line

Wisconsin Central Airlines, a newly organized company, has filed an application with CAB for an airline franchise covering Wisconsin, Illinois, and upper and eastern Michigan. Pres. Francis M. Higgins requests operation over three routes: (1) Chicago to Milwaukee, Oshkosh, Clintonville, Wausau, Rhinelander, and Ironwood, Ashland, and Duluth; (2) from Chicago to Milwaukee, Sheboygan, Appleton, and Clintonville; and (3) from Marquette, Mich., to Iron Mountain, Menominee, Sturgeon Bay, Green Bay, Clintonville, Stevens Point, LaCrosse, Rochester, Minneapolis, and St. Paul.

Aviation Finance

Curtiss-Wright Corp. reports 1943 sales of $1,295,236,317, an increase of 68 percent over 1942 shipments of $770,594,882. Net profits were $12,883,347 or $1.42 a share against $13,143,515 or $1.45 a share in 1942. Earnings were approximately 1 percent of sales, according to Pres. Guy W. Vaughan, while federal taxes were $95,100,000, including a postwar refund of $9,088,000. Current assets totaled $740,000,000 against $715,000,000 the previous year, while current liabilities were $673,548,000 compared with $665,887,000.

Grumman Aircraft Engineering Corp. reports 1943 sales of $278,695,000 against $143,155,930 in 1942, while net income also increased to $3,343,200 or $6.58 a share from $1,335,848 or $2.63 a share in 1942. Profits amounted to 1.67 percent on sales. Further, Pres. Leroy Grumman discloses the company's investment in Liberty Aircraft Products stock, which cost $338,808, has been sold for $675,832. Amount of refund to the government under a renegotiation agreement was $7,629,641.

Brewster Aeronautical Corp.'s V-Loan bank borrowings of $30,000,000 have been paid off by the Navy Department, it is revealed in banking circles. As guarantor, the Navy assumed responsibility for the debt. Liquidation of this claim, also of other outstanding claims and counter-claims, has yet to be settled.

Pan American Airways reports net earnings of $1,929,764 or 97c. a share for 1943 against $3,780,016 or $1.95 a share in 1942. Of total revenues of $126,000,000 last year, 66 percent represented payments for military transport on a contract basis with the government. Gross business the previous year was $106,500,000. The ratio of profits to gross was 1.5 percent.

Bendix Aviation's production averages $75,000,000 a month, Pres. E. R. Breech told stockholders at the annual meeting. The backlog of orders has been reduced from $1,018,901,000 on Sept. 30, 1943 to $750,000,000 as a result of certain Army and Navy contract cutbacks.

Production Outlook: 1943 output represented the peak of Grumman's wartime production, with a slightly reduced rate of output scheduled for 1944. . . . Present backlog of Bendix is equal to about ten months production. . . . Solar Aircraft has a $25,000,000 backlog of uncompleted contracts. . . . Sperry Corp. has 50 new products under development.

Solar Aircraft Co. meanwhile reports sales of $28,065,965 for the year ended Apr. 30, an increase of 25 percent over the previous fiscal year, according to Pres. Edmund T. Price. Net profits were $849,988 or $2.67 a common share.

Sperry Corp. had shipments of $460,006,689 which, based on relative prices, were double those of 1942, according to Pres. T. A. Morgan. Net earnings were $7,592,343 or $3.77 a share against $5,777,961 or $2.87 a share in 1942. Postwar reserves now total $7,250,000.

Luscombe Airplane Corp. stock control has been returned to Leopold H. P. Klotz, of Trenton, N. J., and New York, by James E. Markham, alien property custodian. Mr. Klotz formerly managed the company, which produces naval training planes and aircraft parts.

Briggs Manufacturing Co. reports net profits of $5,239,351 or $2.69 a share in 1943 compared with $4,181,479 or $2.15 a share in 1942. Company officials expect that 1944 output will equal or exceed that of 1943.

Loans: Maximum borrowings by Sperry Corp. subsidiaries last year totaled $75,000,000 and now amount to $59,000,000. The company has a regulation V-credit of $125,000,000 arranged with a group of banks.

Wright Aeronautical Corp. reports 1943 shipments of $579,228,172 compared with $449,545,679 in 1942. Net earnings were $3,599,865 or $6.00 a share against $8,904,711 or $14.84 a share in 1942.

Corporate Changes: Stockholders of Grumman have authorized an increase in the common stock from 600,000 shares to 3,000,000 shares. The directors advised the increase in unissued stock in order to take quick action at any time it becomes advisable to increase the company's working capital.

Ex-Cell-O Corp. reports that net earnings for the year ended Nov. 30, 1943 were $2,554,726 or $6.40 a share compared with net earnings of $2,992,504 or $7.50 a share in the preceding year.

Dividends: Lockheed Aircraft Corp. declared a 50c. dividend payable June 30. . . . McDonnell Aircraft paid a $1.50 preferred dividend on July 1. . . . Solar Aircraft paid the semi-annual 25c. preferred dividend on July 15.

Airline Earnings: Northeast Airlines reported a net loss of $96,950 for 1943 against a profit of $77,097 in 1942. . . . Northwest Airlines reports net earnings of $37,742 for the quarter ended Mar. 31.

Continental Motors Corp. reports net profits of $2,696,185 for the six months ended Apr. 30. Shipments were 11 percent ahead of the corresponding 1943 period.

★ CROSS COUNTRY ★

Passenger Revenue on Northwest Airlines, now reported for May was more than $400,000. During month, 12,867 paid passengers traveled between Chicago, Twin Cities, and Pacific Coast.

United Airlines has completed 1,800 scheduled flights over Alaskan terrain for ATC without serious accident or injury to personnel.

PAA contract for military air transport service in Alaska was scheduled for termination July 31. Though company will continue its regular commercial operations between Seattle and Alaskan points, NATS will take over military services.

Massey & Ranson Flying Service has launched passenger and express service over its Scenic Air Line connecting Denver, Fort Collins, Greely, Boulder, Fort Morgan, and Sterling. Service is two round trips daily between Denver and Fort Collins and one trip daily between Denver and Fort Morgan.

Hawthorn Flying Service has been granted a contract to operate general aero business at Greensboro-High Point Airport. Flying school and charter service is offered.

Mid-Continent Airlines is celebrating its eighth anniversary of transport service.

UAL's airmail traffic for first five months of '44 almost equaled total carried in '42. Five-month total was 6,508,695 mail ton-miles against 6,827,977 ton-miles carried in '42.

Expansion of Rentschler Field, P. & W. airport, has been announced. New control tower, three 5,000 ft. runways, and lighting facilities are planned.

Cia. Mexicana de Aviacion, PAA Mexican affiliate, announces first complete engine overhaul shop in Mexico.

Zimmerly Air Transport Co. recently started trial daily air service between Lewiston and Boise, Ida.

Air Transportation Association of America reveals revenue passenger miles flown by domestic airlines during first half of '44 were 20 percent greater than in first six months of '43. Half-year estimate of '44 mileage is 888,600,000.

Port of New York Authority reveals publication of an azimuthal-equidistant air map with projection centered at New York City. All straight lines eminating at New York represent great circle routes.

CAA reveals program calling for 248 new landing fields on West Coast. Of total proposed, 229 would be small ports suitable for private flying and feeder airline operation.

Aviation Abroad

Robot Bombs Plenty Destructive But Lack Essential Accuracy

Continued use against southern England moves civilians underground again.

Though the U. S. and Britain have, through the years, experimented with robot bombs, it remained for the Germans to introduce them into warfare. The bombs presently being sent into London are judged to be small versions of several types available to the Germans. Whether the larger jet- and rocket-propelled bombs and torpedoes will be used would seem to depend on Allied measures aimed at nipping the menace in the bud. Thus far, the missiles have lacked target precision.

Fact that the bombs explode on contact made initial investigation of their construction difficult, but at this writing considerable data has been compiled. First versions, gaged at speeds up to 350 mpr., were described as having spans of 30 to 35 ft. and closely resembling conventional planes in construction. The large launching platforms were ready targets for our airmen. More recent bombs are from 18 to 20 ft. in span and are thought to be launched from small, simply prefabricated, easily concealed concrete platforms, taking only a few days to construct.

Present type bombs are described as stub-winged flying torpedoes carrying about a ton of explosives. A relatively simple jet motor is mounted over the tail. A single sparkplug is said to ignite the mixture of fuel and air to start the jet operation. After initial sparkplug ignition, firing continues through jet combustion phases. Correct fuel-air ratio is said to be maintained by a spring loaded valve located in the front section of the unit. Spring opens the valve, allowing air to enter the combustion chamber, then, upon ignition, the force of the explosion closes the valve. This action gives a series of interrupted bursts rather than a continuous jet-flow.

That the Germans have solved range and directional problems is confirmed by Mr. Churchill, who states that, through mid-July, approximately 2,750 projectiles have been sent over and, of the number that got through the Channel defenses, the major portion hit London. They have caused 10,000 casualties.

At this writing, interception of the bombs by fighters over the Channel, anti-aircraft fire by guns with predictors, and barrage balloons appear to be the major means of defense.

"'SKITO" NOW TAKES TWO-TON "EGGS"

In its latest modification, versatile RAF "Mosquito" has had bomb bay modified to carry 4,000-lb. bombs. New enlarged bay is marked by underbulge, outline of which is indicated here by lip. Note that bomb being cranked into bay has three sets of fuse-release vanes. Until recently, "Mosquitos" carried four 500-lb. "eggs" in bay and occasionally two additional 500-pounders under wings. (British official photo.)

ON SCHEDULE . . . . . By "VISTA"

An unofficial viewpoint ranging Britain's civil aviation future has been expressed, in a London lecture, by Sir Roy Fedden. As reported in *The Aeroplane*, he particularly drew attention to a general apathy of the British regarding the future of their country's civil aviation, and while he felt the return of RAF personnel to civil life will boost aviation, it will still have to be sold to the public.

He further stressed the need for adequate technical and managerial training to enable Britain to reach its proper place in civil aviation, with faster acceptance of improvements in aircraft. Noted was the fact that many years went by before Britons used retractable landing gear, variable pitch propellers, or monoplane designs.

Internationally, Sir Roy called for immediate consideration of: 1. Control over all enemy territories; 2. settlement of the airbase sovereignty question; 3. international freedom of passage; 4. international security control through an air police force, and 5. international civil air control through a single commission. He further stated that Britain should immediately establish on over-all air policy, reach basic agreements with the U. S., set up a civil aviation department separate from the Air Ministry, and plan both a short- and long-term aviation policy.

Regarding America, Sir Roy expressed belief that the U. S. obviously was out to be the predominant world power in civil aviation, and that Britain must face the fact that the U. S. has an impressive initial advantage. Straight from the shoulder conferences with both the U. S. and Russia should, he said, leave Britain with a fair share of postwar world air transport. The importance of good airports suitable for all aircraft was pointed out, with specific reference to New York City's Idlewild project.

Discussing future aircraft to fill British needs for the period immediately after the war and 10 yr. after the preliminary period, Sir Roy spoke of five types of land planes and one flying boat for the first years, ranging from 8,000 to 160,000 lb., with two to six engines, cruising at 170 to 250 mph.; for the second period, three land planes, from 75,000 to 250,000 lb., and one 400,000 lb. flying boat. Two of the land planes would be powered with turbine-driven propellers and cruise at 325 to 400 mph., while the other land plane and the flying boat would have conventional engines and cruise at 250 to 300 mph. He stated flying boats were given less predominance on the contention that they only come into their own with gross weights exceeding 150 tons, that they entail disembarking difficulties, and that greater efficiency is seen in flying-wing land planes.

★INTERNATIONAL BRIEFS★

Negotiations have now begun in Lisbon for early establishment of a Portuguese airline to Brazil.

Details have now been released on "Griffon"-powered "Spitfire XII". This new edition of "Spit" features elongated "Mustang"-like nose, four-blade propeller, modified bubble canopy, and pointed rudder. Main criticism is very narrow tread of landing gear.

British magazines credit Lockheed "Constellation" with only 210-mph. cruising speed at 70 percent power when making comparison between British and American postwar transport craft.

Reports on reverse lend-lease reveal that British has supplied U.S. with more than 1,100 planes including many "Spitfires", thousands of P-47 droppable fuel tanks, steel landing mats, parachutes, and utilities for U.S. airbases.

British publications have run pictures showing new Douglas A-20 belly ferry tank installed—and mistakenly identifying it as a secret equipment compartment.

More Nazi craft are now getting names. The six-engined BV-222 is called the "Viking", and the new jet-propelled Messerschmitt fighter is the "Swallow".

An artist's conception of Avro "Tudor" (a number of which have been ordered by Dutch KLM), has appeared in "The Aeroplane", and craft is revealed as somewhat similar to DC-4, but with in-line engines. This plane, however, is still in drawing board stage due to pressing military work.

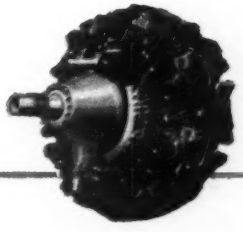
Shipping found a windfall in low-cost luxury travel

The same tremendous market that transatlantic steamship lines discovered 20 years ago is waiting for the introduction of low-cost pleasure travel by air.

In 1924, with immigration reduced to a trickle and the third class quarters of ships running almost empty, one enterprising line modernized these quarters and offered passage to students and teachers at rates 40% to 60% below cabin or first class. Within a few years, this "tourist" traffic equalled the first class business, and by 1937, "tourist" and similar low-rate traffic amounted to 75% of all transatlantic travel.

The mass travel movement which followed World War I can be repeated when air transport rates meet tourist budgets. A world-wide choice of destinations, within quick and comfortable reach during the span of a normal vacation, will attract thousands. More efficient, more economical air transport to make such travel possible is on the way. To the design of new equipment, Wright Cyclones make their contribution in reduced fuel and maintenance costs, with a bonus in payload because of their lighter weight. *Wright Cyclones pay their way.*

Wright Aeronautical Corporation
A Division of Curtiss-Wright Corporation
Paterson, New Jersey, U.S.A.

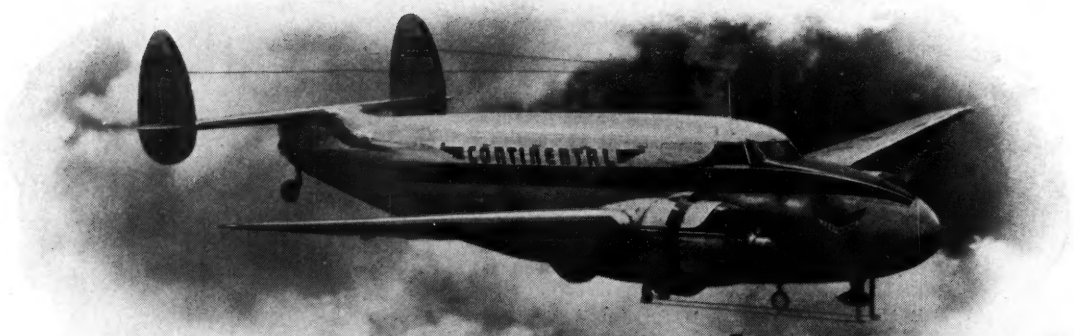


Cyclones Save 3 Ways

LESS WEIGHT—MORE PAYLOAD
LOWER FUEL CONSUMPTION
REDUCED MAINTENANCE

WRIGHT
Aircraft Engines

WRIGHT POWERS THE TONNAGE OF THE AIR



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CONTINENTAL AIR LINES

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UP TO 60 LBS. PER PLANE SAVED BY BOOTS NUTS

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- Will be standard on commercial planes after Victory.
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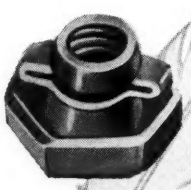
BOOTS WING-STYLE HEX NUT



(W6S 8-32) The comparable fibre-collar nut is 96.4% heavier than this all-metal self-locking steel nut.

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Aviation People

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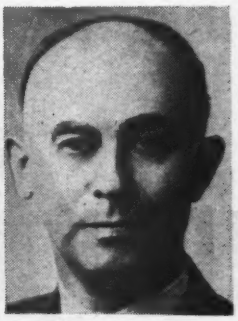

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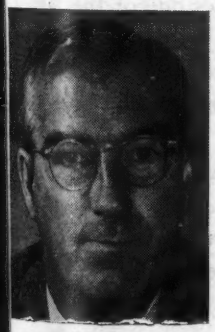

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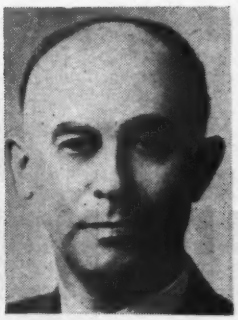

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Review of Patents

By A. HARRY CROWELL, *Registered Patent Lawyer*

FOLLOWING are digests of some of the more interesting recent patents on aviation developments granted by the U. S. Patent Office. Mr. Crowell will gladly furnish readers with free information on approximate cost and procedure in applying for patents and trademark registration. Address inquiries to him, care AVIATION, 330 W. 42nd St., New York City (18). Printed copies of any of patents listed are obtainable at a cost of 10c. each, directly from U. S. Patent Office, Washington.

Airplane Handling Device for manual movement of plane between hangar and line, or in close quarters, consists of dolly on swivelled wheels combined with means for jacking axle of landing wheel. Prior to lowering jack when spotting plane, brake blocks press against ground to prevent rolling of dolly.—2,349,251, filed Sept. 18, 1942, patented May 23, 1944, J. J. Domoj.

Aircraft Selector capable of being held in hand and consisting of plurality of sheets with series of perforations, is operated by "dialing" with stylus inserted in selected holes opposite graphic characteristics of plane observed. Colored dot reveals plane's identity.—2,349,325, filed Dec. 28, 1942, patented May 23, 1944, R. G. Willard and W. H. Van Benschoten.

Gun Mounting for Airplanes. Object of this invention is to provide compact, light, and unitary assembly for rear of guns, plus means for direction and elevation adjustment from a single mounting. It is stated that plurality of mountings can be closely grouped to accommodate a number of guns in relatively small space. —2,350,122, filed Mar. 9, 1942, patented May 30, 1944, J. Martin.

Aircraft Cockpit Canopy is adapted for actuation between open and closed positions during flight, with multi-sections telescoping upon application of force to one of sections.—2,349,630, filed June 10, 1941, patented May 23, 1944, R. N. Lesnick, assignor to Brewster Aeronautical Corp.

Projectile-Plane with twin engines has nose section comprising large caliber armor-piercing explosive shell equipped with time fuse, object being for pilot to aim plane at target as projectile, then leave craft via chute.—2,349,735, filed June 3, 1940, patented May 23, 1944, G. P. Kimmel.

Regulator for Aircraft Carburetors is designed for automatic change to, and holding of, mixture ratio at desired value manually selected by pilot.—2,349,775, filed Jan. 19, 1943, patented May 23, 1944, S. M. Udale, assignor to G. M. Holley and E. Holley.

Parachute invention is concerned with small canopy for use in military pryotechnics. Chute is single piece of paper, or other material, of circular or polygonal shape folded in radial pleats, which are stitched, and shaped at ends to form cord-like tails for attachment of shroud lines.—2,349,833, filed May 15, 1941, patented May 30, 1944, J. H. Robinson.

Adjustable Airfoil is intended to obtain maximum efficiency at both low and high speeds by means of special wing sections which are raised or lowered by motor. Variable camber aims to permit elimination of conventional flaps used to create drag.—2,349,858, filed Mar. 8, 1943, patented May 30, 1944, R. H. Gillmor.

Aircraft Carrier design proposes superimposed decks with novel means for transferring planes from one deck to another, whereby they may land, be refueled and reloaded, and take off in continuous manner.—2,349,930, filed Aug. 1, 1942, patented May 30, 1944, W. H. Atkinson.

Stall Warning Device is aircraft instrument adapted to be fitted to wings. Function is to give pilot visible or audible warning indication when airspeed of plane approaches stalling speed. Instrument has venturi tube attachment and diaphragm with electrical contact point which touches adjustable point at predetermined speed above stalling speed.—2,349,982, filed Oct. 18, 1939, patented May 30, 1944, C. Murray-Waller.

New Aircraft Engine Design aims to secure effective balance and high speed with resultant power gain. Called for are valve structure to facilitate removal and assembly, series of camshafts with novel drive, and special arrangement of rocker arms and connecting rods.—2,349,383, filed Apr. 9, 1941, patented May 23, 1944, A. Scott.

Rotor-Craft Invention specifies supplementary propulsive airscrew. This propeller, with axis offset toward side of craft on which rotor blades advance in translational flight, is designed not only to provide propulsive thrust but also to serve to counteract driving torque of rotor, which may alternatively be power-driven or autorotative.—2,350,126, filed Dec. 4, 1941, patented May 30, 1944, H. F. Pitcairn, assignor to Autogiro Co. of America.

Aeronautical Fuel Control Valve, electromagnetically actuated, is especially designed for controlling flow of fuel, air, or oil. Manually operated controls are eliminated, other than simple light-weight, momentary-contact, double throw switch which may be mounted readily accessible to crew member. Valve is operated by use of solenoids, circuits to which are dead whenever valve is in open or closed position, thus minimizing fire hazard and eliminating draw on electrical power supply of plane.—2,350,352, filed Nov. 8, 1941, patented June 6, 1944, J. Harding, Jr.

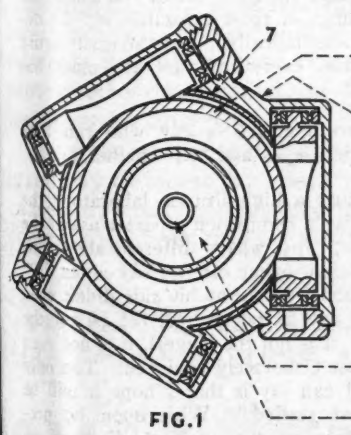

FIG. 1

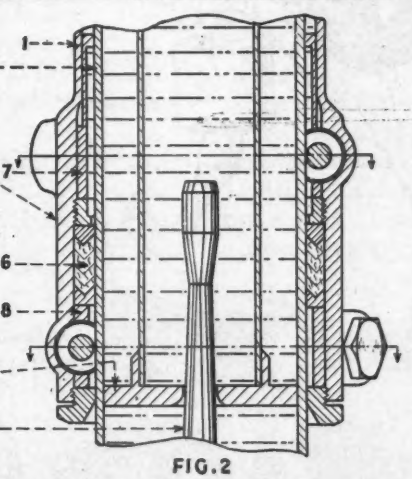

FIG. 2

Developed as improvement for shock struts, roller mechanism (shown in transverse partsectional view in Fig. 1) is designed to minimize friction and eliminate jamming of telescoping cylinders. Referring to Fig. 1 and 2, details of strut are: Outer cylinder (1), inner cylinder (2), piston (3), and metering pin (4). Outer cylinder has enlargement (5) which houses annular packing (6), sleeve (7), and ring (8). A set of rollers (Fig. 1) intercepts sleeve (7) and another set intercepts ring (8). Rollers which have longitudinal contour to fit transverse contour of inner cylinder surface, are supported at ends by ball nearings.—2,349,957, filed Nov. 12, '41, patented May 30, '44, L. Greve, assignor to Cleveland Pneumatic Tool Co.

Book Reviews

RADIO DIRECTION FINDERS, by Donald S. Bond. McGraw-Hill Book Co., N. Y. 287 pages, diagrams, index. $3.

Text and reference work for electrical engineers specializing in the design or theory of direction finders for aircraft, shipboard, or fixed station use. It combines qualitative description of practical systems in use with an analytical study of the underlying phenomena. Comprehensively written, the information is highly detailed.

BOMBERS ACROSS, by Capt. Edgar J. Wynn. E. P. Dutton & Co., N. Y. 178 pages, $2.50.

Saga of Air Transport Command and its vital part in the war, told by a man intimately connected with its history. The book introduces the reader to the annals of the ATC and to the pilots who have been the author's companions along the airways across ocean, desert, and jungle, graphically picturing the obstacles these men have had to overcome to bring the ships through to the fighting fronts in the many war theaters.

PRODUCTION, JOBS AND TAXES, by Harold M. Groves. McGraw-Hill Book Co., New York. 112 pages, index, $1.25.

This volume is the first of a series sponsored by The Committee For Economic Development. Herein is covered postwar revision of the federal tax system to help achieve higher production and more jobs. Mr. Groves, an economic professor at the University of Wisconsin, makes recommendations concerning the role of the aviation industry as an important employer in postwar America.

AAF, THE OFFICIAL GUIDE TO THE ARMY AIR FORCES. Simon & Schuster, New York City. A directory, almanac, and chronicle of achievement; 64 pages of photographs; 175 drawings, charts, and maps; completely indexed; $2.50.

Attack, today, is the by-word on all fronts. Leading, supporting, and covering these attacks are the vast Army Air Forces. Here is a timely volume compiled by the AAF to give a better understanding of their organization, personnel, equipment, and supply and operational problems. Subjects are covered in concise non-technical language, and there is a wealth of photographs, drawings, charts, a war calendar, and a full index. This volume will serve as a question-and-answer reference concerning our air arms.

MATHEMATICS FOR AIRCRAFT ENGINE MECHANICS, by Harold Griffiths. McGraw-Hill Book Co., New York. 325 pages, appendix, illustrations, index, problems, $2.50.

A text book on the theory and repair of aircraft engines for the student mechanic. The material is presented in conjunction with practical examples, giving the student a direct insight to the problems he will have to work with in the shop. Special attention is given to a review of the fundamentals of arithmetic, a frequent weakness of student mechanics. The volume also aims to be of aid to pilots studying for CAA commercial ground school examinations. It can be used as a supplement to the CAA's power plant manual. Author Griffiths is an instructor for The Embry Riddle School of Aviation.

AIRCRAFT MECHANICS HANDBOOK, edited by Paul Van Winkle. The Manual Arts Press, Peoria, Ill., index.

A reference book for mechanics, engineers, technical men, and workers responsible for the repair and manufacture of aircraft and aircraft parts. The volume contains latest A and N specifications on aircraft material and technical data, with sections on identification, replacement, and repair of parts and accessories.

(Turn to page 314)

Side Slips

SPEAKING OF PLEASING the customers, we saw an ad the other day depicting a gargantuan, multi-jet-propelled flying wing (yes, the usual helicopters were seen hovering around about 50 ft. above it) with a complete, brass-railed bar in each transparent, unbraced wingtip. But what should really please the customers was the grandiose installation right in the top surface of the center section—nothing less than a cute outdoor swimming pool. Said the man looking over our shoulder, "How to kill off designers as well as customers in one easy air brush lesson."

• The All American Airlines pilot was flying serenely along his pickup route under what seemed to him good weather when a new operator in the control tower at his destination said he'd better land at another place; ceiling was getting pretty low. When the pilot kept coming, the operator got worried and again advised the ceiling was too low for a landing. Finally the pilot called in and asked, "Just exactly what is your ceiling there?" Back came the answer, "Two hundred and fifty feet." "Good lord," retorted the disgusted pilot, "if I ever got up that high I'd need oxygen."

• As is well known, reputations for sophisticated imperturbability are highly cherished by Army sergeants. But not all of them manage to keep their *savoir faire* unsullied. There's the case of the three-striper who got himself a ride in a B-29 *Superfortress.* As the huge bomber roared for the takeoff, this fellow's worldly wise eye happened to alight on the plane's wing—and when he saw the broad flaps roll out away from the trailing edge his jaw dropped to his chest with a force not far short of 9-G's. *"Stop-p-p the plane!"* he shouted up to the bridge. *"The flaps are falling off!"*

• You might say that most "bugs" in airplanes are problems weighing merely on the manufacturers. Yet there was a bug in the B-29 which not only had all the good Boeing people baffled but, frankly, was so very insidious that it also tangled up the editors all over the country. To put it briefly: Should the big bomber's name be spelled *Super Fortress* —or *Superfortress?* On the one hand, the plane's embossed nameplate gave it as two words; on the other, Boeing PR releases had it as one. But some courageous executive has finally come forward and ironed it all out, saying in effect: "We don't give a hoot what the nameplate on the ship says—spell it *Superfortress.*"

• That isn't the end of the perplexities, though—for a letter printed in the readers' column of our favorite newspaper points with some alarm to still another B-29 name hazard. This correspondent visions the plane-namers as being very much stuck when they try to augment *"Superfortress"* into a new tag for the next-bigger bomber which comes along. This fellow does mention the possibility of *"Superduperfortress,"* but in the very same sentence he abruptly casts it out as an unsuitable solution. Alas, yes, this a question to give men pause.

• "Cabin pressurization" is a term haunting more and more designers. At a recent discussion of the problems, one man wanted to know the best level at which to maintain pressure—should it be 8,000, 10,000, or just what altitude is best? To which another promptly replied, "Keep it down to sea level." Asked why, this man countered: "Did you ever, at 8,000 or 10,000 ft., open a bottle of club soda for a highball, and see the whole thing blow away, just like steam? Keep your cabin to sea level pressure, mister, keep it down to sea level."

That particular designer took the bar customers seriously. Seems he once had to design a 36-passenger job, and the specs called for a lounge, capacity 20, plus a bar, capacity 16. "When you put a bar and lounge of those capacities in," he declared emphatically, "you can just figure on putting everything else any place but at CG."

• Meteorologist is a guy who can look in a girl's eyes and tell whether.

• Visiting a high-altitude laboratory the other day a companion reporter asked the director, "Just what's different about this installation—what can we say about it?" The publicity man at his side didn't even bat an eye as he replied, "It is not the newest, it is not the biggest, it is not even the most elaborately equipped. The only thing I can say is that I hope it will be the best staffed." Whereupon he presented us to the medical director—an efficient and thoroughly attractive young lady, a Miss as well as a medico. Somehow our companion reporter lost interest in the other staff members—just agreed the director was well on his way to getting the kind of staff he should have.

"Parachute nothing—Maguire's going on a picnic and that's his lunch."

The loss of recoverable alloys in steel scrap has been a major problem confronting the various conservation agencies. Proper segregation of scrap is one effective answer.

Segregation of scrap at the source is comparatively simple. The difficulty comes in preventing mix-ups in subsequent handlings. They can be prevented or remedied by applying two simple tests—spark and spot.

The presence of molybdenum, or nickel, or both, is readily detected by spark testing. Molybdenum causes an easily recognized secondary burst at the end of the spark stream resembling a spearpoint. Nickel produces a spot of intensely white light in the stream near the grinding wheel.

Both elements have a tendency, in the higher contents, to suppress the supplemental bursts characteristic of carbon steels.

Several spot tests for molybdenum have been developed. The simpler ones depend on the red color produced by either potassium ethyl xanthogenate or sodium thiocyanate added to a molybdate obtained from the etched surface of the steel. The dimethyl glyoxime test for nickel also depends on a red coloration. Many of these tests are approximately quantitative.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

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MOLY

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Products and Practices

This selected information on new publications and products is offered by the "AVIATION" Reader's Service through cooperation with the manufacturers. It helps executives save valuable time, provides profit through convenience. To obtain literature or additional data on new products described, simply fill in form below, clip it to your letterhead, and mail. There is no cost, no obligation.

ENGINEERING DATA

Aircraft Controls 1

Story of development of group of advanced aircraft products by Simmonds Aerocessories, New York City, is presented in illustrated brochure. Titled *Simmonds Products Fly With Famous Planes*, publication describes automatic engine control, precision push-pull control, hydraulic fuse and chromatic radiosonde.

Thermosetting Synthetic Resin 2

"Duralon", recently developed by U. S. Stoneware Co., Akron, is new thermosetting synthetic resin made from waste agricultural products. Numerous possible applications are being considered. Its chief importance at present is as an impregnant, a laminating and bonding agent, or as a protective coating material. Properties are described in bulletin.

Molded Aircraft 3

Duramold process of molding light, fibrous materials into aircraft parts is explained in new booklet from Fairchild Engine & Airplane Co., New York City.

Aircraft Fastener 4

Technical data on spring-lock fasteners made by Elastic Stop Nut Corp., Union, N. J., is presented in booklet showing specifications, sizes, and detailed tests.

Aircraft Control Devices.....5

Hydraulic control devices for aircraft, such as valves, cylinders, positioners, and pedal and rudder assemblies are described in booklet, *Aircraft Control Devices* published by Automatic Products Co., Milwaukee.

Small Motors 6

Developments in design of fractional hp. motors are told in brochure, *Out of Thin Air*, offered by Dumore Co., Racine, Wis. Types suitable for aircraft use are illustrated and described.

Aircraft Heating Devices.....7

Electrical heating devices to insure operation, at low temperatures, of guns storage batteries, and other installations, are illustrated and described in booklet, *Controlled Electric Contact Heat*, published by H & A Mfg. Co., Binghamton, N. Y.

Microfilming Drawings 8

New application of microfilming to pencil engineering drawings is described in new booklet, *Hold Everything*, issued by Microcopy Corp. Burbank, Calif.

Adhesive Catalog 9

B. F. Goodrich Co., Akron, has issued new catalog section on its line of adhesives and cements, discussing service requirements and classification of various items.

Petroleum Refining 10

Technical data on processes for refining 100 octane gasoline, and aviation lube oils is offered in new booklet issued by the Lummus Co., New York City. Photographs of recent plant construction and many flow diagrams are included.

PRODUCTION

Resistance Welding 11

General Electric Co., Schenectady, N. Y., offers new booklet, *Resistance Welding, a Modern Method of Metal Fabrication*, covering such subjects as: Resistance welding methods and equipment; selection of equipment; welding electrodes and their maintenance; and materials and their preparation.

Abrasive Cutting 12

Campbell Abrasive Cutting Tip Sheet is bulletin published by Andrew C. Campbell Div., American Chain & Cable Co., Bridgeport, Conn., describing various abrasive cutting machines and listing their uses.

Metal Protection 13

Metal protection through application of paint coatings, with special emphasis on zinc pigments, is described in booklet issued by New Jersey Zinc Co., New York City.

Blow Torches, Fire Pots.....14

The Story Behind the Turner Brass Works is booklet just published by Turner Brass Works, Sycamore, Ill., describing company products and organization.

Screw Machine Catalog.....15

Standard screw machine items and drawings of special items produced by Progressive Mfg. Co., Torrington, Conn., are shown in new catalog, *Machine Screws & Specialties*. Included are tables showing standard weights per thousand, and decimal equivalents of fractions.

Aircraft Instrument Repairs.....16

Henry Paulson & Co., Chicago, offers booklet *Construction, Maintenance and Repairing of Aircraft Instruments*. Material is reprinted from *Horological Journal*, London.

Quenching Steel Castings.....17

Lebanon Steel Foundry, Lebanon, Pa., has published booklet titled *Water Quenching Requirements for Steel Castings*. Featured are charts and specifications.

Gas Cutting Guide 18

Pocket-size, slide-type guide showing proper tip sizes, gas pressures and other data for machine gas-cutting of steel of various thicknesses is offered by Air Reduction Sales Co., New York City.

Pattern and Model Making.....19

Manual of pattern and model making with gypsum cement has been published by U. S. Gypsum Co., Chicago. Methods and practices are illustrated and explained.

Universal Joints 20

Aircraft joints are illustrated in circular from Apex Machine & Tool Co., Dayton Ohio. Tables of specifications, also torque and deflection data, are given.

Reclaiming Agent 21

Information on "Traversite," reclaiming agent designed to prevent corrosion of metal back-set and overspray from fouling flood sheets, nozzles, and circulating system. is offered by Penetone Co., Tenafly, N. J.

Aircraft Cleaner 22

Handbook on cleaning, polishing, and waxing of aircraft is offered by Autogroom Co., Woodside, L. I., N. Y.

Aircraft Valves 23

"Y" and other type valves for aircraft are shown in new catalog from Koehler Aircraft Products Co., Dayton, Ohio. Data, drawings, and specifications are given.

AVIATION READER'S SERVICE

AUGUST 1944

AVIATION, 330 W. 42nd St., New York City

Please send me additional information according to key numbers circled.

INFORMATION TIPS						1	2	3	4	5	6	7	8	9	10	11	12
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31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54												
NEW PRODUCTS						55	56	57	58	59	60	61	62	63	64	65	66	67	68
69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110												

NAME..... TITLE.....

FIRM OR AFFILIATION.....

ADDRESS.....

Care of Spray Equipment.....24

DeVilbiss Co., Toledo, offers wall chart showing steps in caring for spray guns, paint cups, hose, transformers, compressors, booths, and fans.

Thermometer Bulb Insert.....25

Information on "Rosan" thermometer bulb insert, used in tank and plumbing installations, and of interest to aircraft power plant engineers is issued by Bardwell & McAllister, Hollywood, Calif.

MACHINERY & ACCESSORIES

Grinding Wheels 26

Bulletin descriptive of tungsten diamond impregnated burrs and wheels is issued by Champion Diamond Co., New York City. Burrs and wheels are of mixture of tungsten powder and diamond grit. They are stated to be suitable for use on tungsten steel dies.

Portable Electric Drill.....27

Brochure covering history, development, features, and specifications of new Thor plastic-housed portable electric drill is issued by Independent Pneumatic Tool Co., Chicago. Data answers questions relative to stamina of plastic housing.

Hardness Testing 28

Brinell hardness-testing machines are described in new catalog from Olsen Testing Machine Co., Philadelphia. Equipment for all types of materials and products are shown, and included Brinell hardness numbers, specifications, and data on parts, attachments, maintenance, and operation.

Scanning Internal Surfaces.....29

Internal Surface Projector Co., New York City, offers new booklet on its machine for scanning and photographing condition of internal surfaces, such as cylinder barrels in aircraft.

Tangent Bender 30

Edge bending of aircraft parts, as an application of Struthers Wells tangent bender, is described in folder from Struthers Wells Corp., Titusville, Pa.

Liquid Temperature Control 31

Bulletin 96 from Niagara Blower Co., New York City, describes new balanced wet bulb temperature control for company's "Aero" heat exchanger, designed for cooling and maintaining temperatures of liquids or gases.

Cutter Sharpener 32

Folder by Edw. Blake Co., Newton Center, Mass., gives details of new cutter sharpener, with operating instructions and information on correct sharpening practice.

Pyrometer-Recorder 33

"Rayotube", a scanning and recording device used in connection with pyrometers and other instruments, is described in booklet published by Leeds & Northrup Co., Philadelphia. Contains illustrations of various applications.

Crank Shapers 34

Bulletin GC-12 from General Eng. & Mfg. Co., St. Louis, describes three types of multi-purpose crank shapers and gives specifications on company's various machines.

Aircraft Precision Units.....35

Bomb shackles, gun chargers, actuating cylinders, valves, and other aircraft precision units are described in folder from Interstate Aircraft and Eng. Corp., Los Angeles.

Tap Extractors 36

Specifications, sizes and other information on tap extractors is given in new bulletin from Walton Co., Hartford, Conn.

External Indicating Gage.....37

Air flow medium is used in conjunction with "Metricator", external measuring gage described by Metrical Laboratories, Ann Arbor, Mich., in bulletin just issued.

Lathe Catalog 38

Catalog No. 150 describes engine, toolroom, and turret lathes made by South Bend Lathe Co., South Bend, Ind. Tabulated is information concerning speeds, capacities, feeds, and dimensions.

Injection Molding Machines 39

Bulletin from Lester-Phoenix, Cleveland, offers specifications on injection molding machines.

Production Tools 40

Acme Tool Co., New York City, announces new catalog No. 44 describing precision production tools.

ELECTRICAL

Electrical Measurements 41

Electrical measurements, their industrial applications, and explanation of bridge controlled oscillator are covered in issue of *General Radio Experimenter* published by General Radio Co., Cambridge, Mass.

Electric Switchboard Plugs.....42

Electric laboratory and switchboard connector bulletin from Cannon Electrical Development Co., Los Angeles, contains information, photographs, drawings, and data on line of specialty fittings, including sub-mounting plugs and receptacles, straight cord plugs and receptacles, switching plugs, and experimental switchboards.

Aircraft Instruments 43

Standard line of Kollsman aircraft flight, avagational, and engine instruments are described in new condensed catalog published by Kollsman Instrument Div., Square D Co., Elmhurst, N. Y.

Hydraulic Remote Control.....44

Bulletin of Sperry Products, Hoboken, N. J., describes "Exactor" hydraulic remote control which makes use of single tube system to enable bending around obstacles and passing through various obstructions.

Electron Tubes 45

Ken-Rad Tube & Lamp Co., Owensboro, Ky., has published booklet on essential characteristics of company's electron tubes with technical data and applications.

Insulation Tester 46

Bulletin, descriptive of model B-5 megohmer battery type insulation tester is offered by Herman H. Sticht Co., New York City. Shown are triple color scale, and contained is chapter on value of periodic insulation resistance measurements as recorded on megographs.

Industrial Controllers 47

Information from Wheelco Instrument Co., Chicago, concerns "Inputrols", new instrument for control of input of power, heat, or flow of liquids or gases.

Electric Sander 48

Portable electric sanders is subject of new bulletin from Stering Tool Products Co., Chicago.

STEELS & PLASTICS

High Speed Steel 49

Bulletin issued by Jessop Steel Co., Washington, Pa., gives analysis of company's Purple Label extra high speed steel, together with working data on forging, annealing, grinding, hardening, and tempering.

Alloys 50

Some Basic Facts about Cerium, from Cerium Metals Corp., New York City, contains description of this metal and its application in the delivery of master alloys.

MANAGEMENT AND EMPLOYEES

Welding Process Film 51

New film prepared by Navy on aircraft welding is available, through American Welding Society, New York City, for instructural showings.

Avoidance of Waste.....52

How to Cut Waste, manual for use by foremen, supervisors, and department heads showing sources and avoidance of waste, has been issued by Elliott Service Co., New York City.

Employee Relations 53

Addressed to "production men who still like to get their hands dirty", *The Middle of the Shop* is brochure that presents new approach on employee relations. It is issued by Sav-Way Industries, Detroit.

AIRPORTS

Waterproofing Soil 54

Ending mud by waterproofing soil is purpose of "Stabinol", new development of Hercules Powder Co., Wilmington, Del. Data is available to airportmen.

NEW PRODUCTS

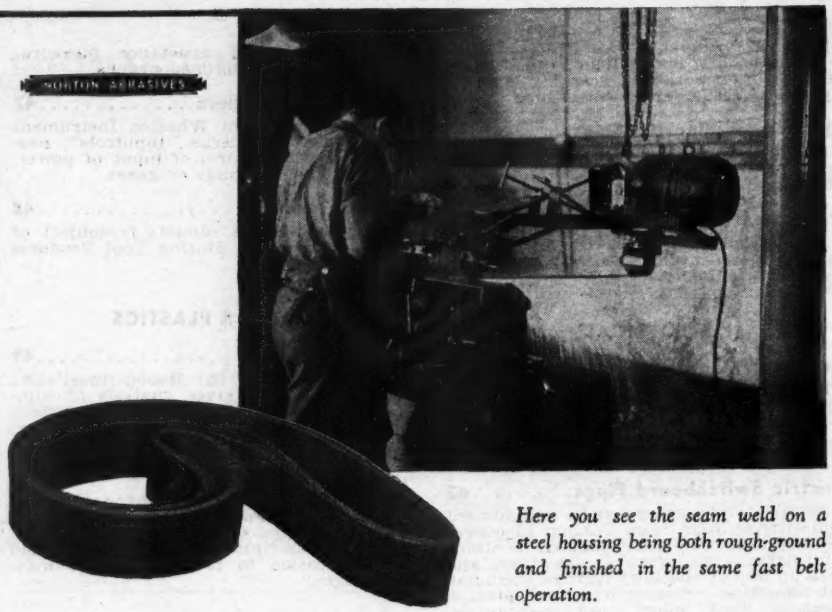
Latest Machine Tools

High Speed Carriage Drills.....55

Designed by **Paragon Research**, Buffalo, and manufactured by Farnham Mfg. Co., Buffalo, is new line of high speed carriage drills for production drilling of aluminum alloy spars, wing panels, and other long assemblies. Units are furnished complete, ready for installation on rails fastened to assembly fixture. A variety of carriage mountings is available, both horizontal and vertical. For curved surfaces, carriage unit is available which is controlled by cam, keeping drill perpendicular to contour of work. Drill feed, drill depth, and return stroke are automatic. After locating drill unit and depressing thumb button, automatic cycle is as follows: Pressure is applied to drill bushing to hold unit firmly; drill follows with fast feed; when drill reaches work, adjustable feed automatically slows down; and when stop is reached, drill returns to starting position.—AVIATION, Aug., '44.

Automatic Plating Machine.....56

Udylite Corp., Detroit, states it has developed a "packaged" fully automatic plating machine which can be shipped assembled in one freight car and installed by buyer's own men. Outfit measures 35x6x9 ft. and weighs 13,500 lb. Incorporated is new square type transfer system to permit wide variation of transfer speeds—lift, lowering, and transfer rate



Here you see the seam weld on a steel housing being both rough-ground and finished in the same fast belt operation.

Note the shower of sparks! Yet the belt disperses heat quickly.

METALITE CLOTH BELTS
Improve Swing Frame Grinding

NATURALLY! Their greater area and sharper surface obviously provide cooler, faster cutting and better finish.

A maker of stainless steel tanks for milk trucks, where finish was paramount, was influenced by one of our men to adopt this modern method for polishing the entire inside of the huge saucer-shaped ends.

Result: One man, one shift, now keeps ahead of a schedule that formerly required two men, two shifts.

If you run a Swing Frame Belt Grinder, send for our brochure "Metalite Cloth Belts Improve Swing Frame Grinding." If not, we can send you manufacturer's literature on the Grinder itself. Here's a handy coupon.

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Please send the following literature:
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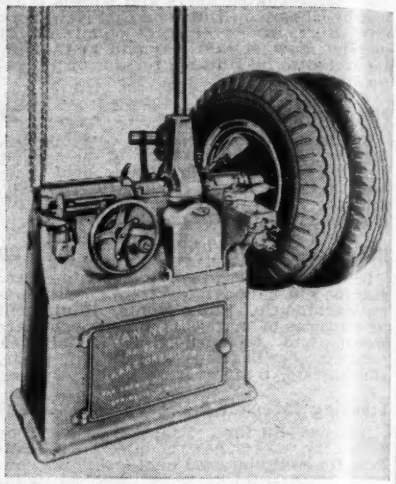
being variable independently. Racks are spaced on 18-in. centers, but spacing may be varied without adjustment of transfer mechanism. Single row carrier system handles up to 76 racks per hour. Single hydraulic mechanism is employed. Steel superstructure is counterbalanced so that transfer mechanism lifts only weight of eight loaded racks at one time.—AVIATION, Aug., '44.

Brake Drum Lathe.....57

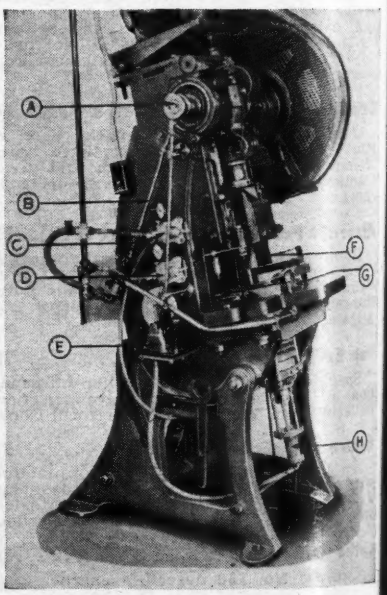
Heavier base-casting, designed to accommodate brake drums of aircraft wheels, is feature of No. 303 brake drum lathe made by **Van Norman Co.**, Springfield, Mass. Also new is independent heavy duty grinder attachment to finish-grind cast iron drums at same time drums are being turned. Hollow spindle



is supported by large bronze-backed babbitt bearing; and bearing both revolves and slides horizontally. Has five feeds forward and five in reverse, together with three speeds.—AVIATION, Aug., '44.

Cushion Blanking Dies.....58

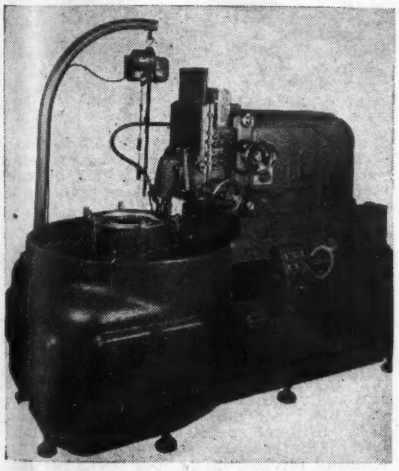
Flat die-cut stampings are now custom-produced by new process using cushion blanking dies developed by **Dayton Rogers Mfg. Co.**, Minneapolis. Method is designed primarily for production of limited number of parts. Referring to photo, by use of special sub-bolster (G), blanking punches from 38 in. to ⅝ in. thick can be fastened thereon. Special hardened and ground stripping pins are nested around blanking punch, passing through this universal sub-bolster plate (G) and are controlled for stripping action by standard pneumatic die cushion fastened to press bed frame. Blanking die is supported by stripping pin and is



brought into blanking action by special punch pad (F). Two cams are fastened to punch press crank (A) controlling two valve rods (B) and (C) which open and close two air valves (E). Combination pressure gage and regulator allows operator to increase or decrease air pressure required on pneumatic die cushion, including smaller air cylinder (H) which operates an ejector which removes blanks after punching. Piercing operations are done on secondary set-up. Die cut blanks .005 to ⅛ in., up to blanking pressure of 100 tons, can be produced. Control mechanism on tooling is pneumatic.—AVIATION, Aug., '44.

Gear Tooth Shaver 59

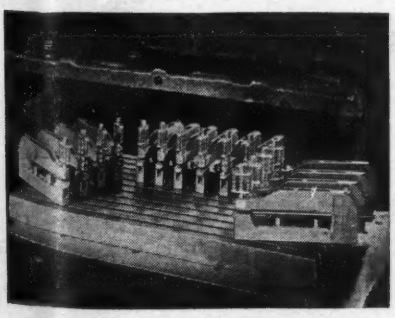
National Broach & Machine Co., Detroit, announces the GCQ-36 in., new gear tooth shaving machine for finishing internal and external gears from 12 in. to 36 in. P. D. Principle of rotary crossed axes shaving is used, but work is carried horizontally on power driven rotary work table. Teeth of work gear mesh with those of cutter which, free to rotate, is driven by work gear and at same time is slowly reciprocated across face of work gear in a direction parallel to its axis. Cutter is fed into work gear one increment at each reversal of direction in its reciprocating motion. Final tooth size is controlled by total amount of in-feed over entire cycle. Work can be lowered directly onto table since there are no obstructions, and power hoist is furnished as optional equipment. Work ejector is controlled by foot pedal. Principal operating elements are work table, quick clamping fixture, and horizontal feed slide. As cutter and work rotate, cutter head moves slowly downward at selected rate of between .004 and .016 in. per work gear revolution. At lower end of stroke, table rotation is reversed, cutter is fed one increment into work gear, and head starts its upward stroke—all



automatically. Same action takes place when head reaches top of stroke. After several such strokes, in-feed is disengaged and machine idles through one or more additional strokes to asure maximum smoothness of tooth surfaces.—AVIATION, Aug., '44.

Hole Punching U nits.....60

New hole puncaing units, Type "BC", are announced by Wales-Strippit Corp., North Tonawanda, N. Y. They are designed to punch unlimited number of



straight line, scattered, and staggered hole patterns with varying center-to-center distances, also square sheared and curved sheets and long strips of flat material may be perforated. Group of units may be used interchangeably in press brakes and stamping presses by mounting on T-slotted plates, templates, and rails. Units comprise punches, dies, and stripping guide assemblies, held together by holders, as independent, self-contained units. Holders also retain punch and die in alignment. Nothing is attached to press ram since ram only operates to depress punch through material. Punch is full floating. Die is a press fit into holder and may be tapped out through slug clearance hole by bent rod. It is stated various diameter holes up to 5/16 in. may be punched with same unit by simply changing punch, die, and stripping guide assembly. Three-spring stripping guide assemblies provide pressure for holes up to 5/16 in. in material up to ⅛-in. thick. Throat depths are 4, 7, and 9 in. Photo shows units on T-slotted plate for punching holes along edges of square sheet.—AVIATION, Aug., '44.

Hydraulic Vise 61

"V"-way hydraulic vise, manufactured by Reimuller Bros., Franklin Park, Ill., is designed to meet mass production requirements. Unit can be mounted vertically and used for production press on small precision upsetting, heading, and other small operations requiring dies or tooling. Two levers are used in hydraulic foot control, one to apply pressure and the other for release, which has a two-speed return. No outside air lines

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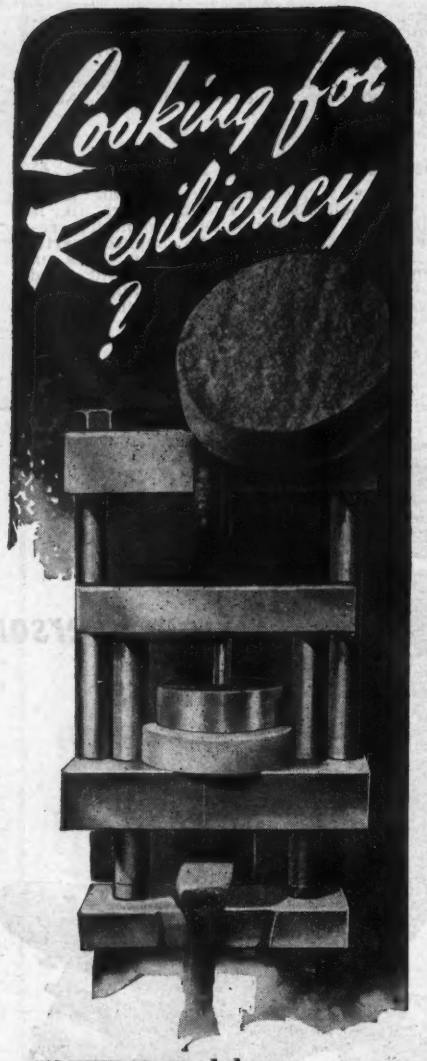

IN EXTENSIVE laboratory tests, the compression of certain (½-inch thick) Booth felt samples under load of 150 lbs. per sq. in. resulted (after load removal) in "permanent" loss in thickness of only .005 inch!

Yes, Booth "prescription" felt manufacture can be controlled to give you the amount of resiliency, or almost any other quality, desired in your material.

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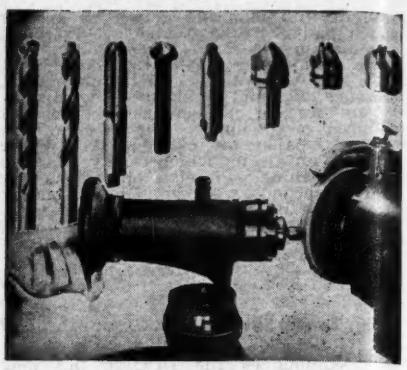
PRECISION CUT FELT PARTS

or power is needed and unit is self air eliminating. Flexible hydraulic hose makes unit portable. Two sizes are available: 4 ton with 4 in. opening, and 7 ton with 7 in. opening.—**AVIATION, Aug., '44.**

Grinding Fixture 62

Designed originally for grinding countersinks, I-G-C relief grinding fixture is now being used for drills and taps, reports maker, **Accurate Machine Products Co.**, Los Angeles. Grinder will take work from 1/16 to 1 in. dia. and with any number of flutes up to twelve with exception of 5, 7, and 10. Fixture is designed to fit any standard grinding machine, and it works with either right or left hand taps and cutters.—**AVIATION, Aug., '44.**



Shop Equipment & Accessories

Liquid Contents Indicator.....63

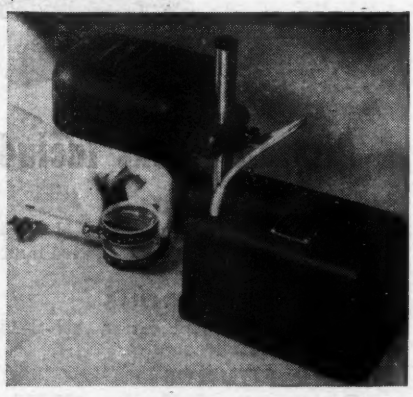
Techtmann Industries, Milwaukee, announces that its "U-C" liquid contents indicator is now offered in form adaptable to 30-gal. steel drums, as well as 55-gal. drums.—**AVIATION, Aug., '44.**

Aircraft Heating Unit.....64

Known as "Hexheat", new heating unit for aircraft is announced by **Drayer & Hanson,** Los Angeles. Of tube construction, airflow can be arranged for cross-flow, co-current-flow, or counter-flow. Unit uses exhaust heat for wing de-icing, cabin heating, etc.—**AVIATION, Aug., '44.**

Optical Flats 65

Continental Machines, Minneapolis, announces optical flats made of fused Brazilian quartz which has hardness of 7 on Moh scale. Six sizes in dia. of 2, 3, 4, 5, 6, and 10 in. are available and carry accuracy guarantees of one millionth for laboratory gage block and instrument inspection, and two millionths for checking instruments and fine tools.



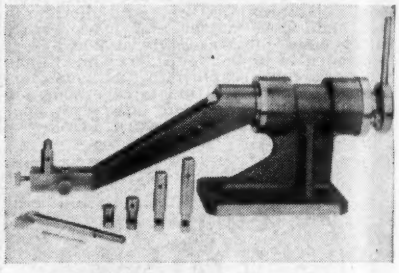
Used in connection is the Doall Monolight, monochromatic light using helium light rays having one wave length only and a distinguishable color—yellow. Rays from this light, when observed through optical flats, produce interference bands of 11.6 micro inches, which bands are used to measure flatness, height, and parallelism. Specifications: Maximum height lamp to table, 12 in.; minimum height lamp to table, 8½ in.; projection head tilts 90 deg. up and 21 deg. down, and it rotates 360 deg. Net weight is 12 lb. Current 110v. 60 cys., single phase.—**AVIATION, Aug., '44.**

Self-Locking Nut 66

New nut made by **Stover Lock Nut & Mach. Co.,** Easton, Pa., is one-piece and self-locks through a compressing process which makes upper threaded portion slightly elliptical and leaves lower portion circular. Maker says nut does not harm bolt threads and may be re-used.—**AVIATION, Aug., '44.**

Radius Dresser 67

Radius dresser with capacity to 4½ in. radius, Model No. 45, is announced by **U. S. Tool & Mfg. Co.,** Dearborn, Mich. Furnished with three different length



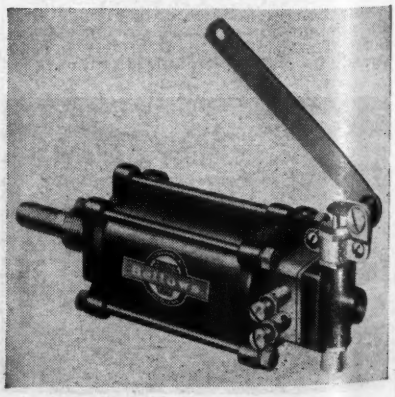
diamond holder bushings, graduations are etched on chrome plated ring, together with lock-stop on spindle which provides means for exact location of radius desired.—**AVIATION, Aug., '44.**

Miniature Inductor Coils 68

Small air inductor coils introduced by **Barker & Williamson,** Upper Darby, Pa., are stated to offer wide range of engineering possibilities in high frequency radio and other electronic applications. Supplied in diameters from ⅛ in. to 1¼ in., any type mounting can be supplied and coils can be equipped with fixed or variable, internal or external, coupling links, to meet specifications. Five standard diameters are each available in any winding pitch from 44 to 4 turns per inch, or less. Wire sizes range from #14 to #28.—**AVIATION, Aug., '44.**

Air Motor 69

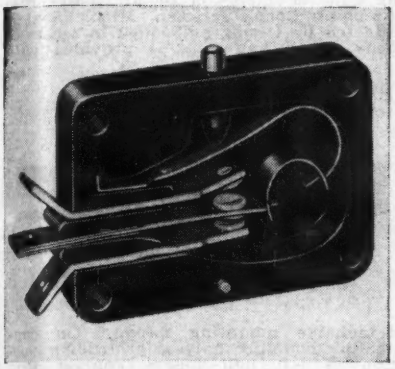
Bellows Co., Akron, announce new air motor, application of which is stated to make many hand operations fully automatic. Model BM is for use on such operations as feeding work to tools, tools



to work, opening and closing vises and holding fixtures, and operating clutches and latches. Provided is source of flexible power for various staking, clamping, and embossing operations. Model BM is a complete self-contained unit with integral valve, operating lever and speed controls. Operating lever is adjustable to any angle and may be synchronized by simple linkage, cam or solenoid controls to machine cycle. Dual exhaust throttle controls permit speed regulation. Air exhaust stream can be used to eject parts or clean chips away. Operates on any air pressure up to 175 psi. Power thrust is approximately five times air line pressure. Motor is available in strokes from 1½ to 48 in.—AVIATION, Aug., '44.

Snap-Action Switch 70

New "Miniac" snap-action switch, made by **Acro Electric Co.**, Cleveland, is 17/64 in. thick, 13/16 in. high, and 1-1 3/16 in. long, fully enclosed in bakelite case with four mounting holes. Engineered on rolling spring principle, actuation is with stainless steel plunger. Rated at 15 amps., 115v. a.c., it is furnished in single pole, normally open and normally closed, double throw. Designed to permit leaf type or overtravel plunger type actuators to be attached to case.—AVIATION, Aug., '44.



Refrigeration Units 71

Among improvements reported for new industrial refrigeration units made by **Frostrode Products**, Detroit, is new evaporator coil arrangement to eliminate sharp bends, minimize back pressure of refrigerant, and permit unrestricted flow of coolant. Refrigerant expansion valves are stated to have increased sensitivity to temperature variations. Line now comprises four basic standard units: Models 751, 1501-E, 3002, and 5001, designed to maintain 0 deg. F. to 10 deg. F. coolant temperature during continuous production runs of one, two, four, and six light aluminum welders, respectively, or equivalent load of steel welders or other machines.—AVIATION, Aug., '44.

Ratchet Wrench 72

New pneumatic ratchet wrench has side plates which support socket and are milled with slots entire length of plates to provide accurate alignment and rigid supports for socket. Also new strength in pawl is accomplished by two ratchets engaging teeth of socket, with two springs for balanced pressure at point of contact with ratchet. Tool is available in three sizes, with sockets for use on nut running jobs from ¼ to ⅝ in. Maker is **Keller Tool Co.**, Grand Haven, Mich.—AVIATION, Aug., '44.

Detachable Hose Coupling 73

Detachable brass coupling for helical flexible metal hose in sizes from ⅜ in. to 1½ in. i.d. has been developed by **Packless Metal Products Corp.**, New Rochelle, N. Y. Said to be mechanically self-sealing, no brazing is employed. Unit consists of nut, back, stem, and split ring. When assembled, convolutions of hose and metal braid are securely held by pressure between members. There is self-contained union to permit pipe thread end of coupling to be screwed directly into machine fitting, and union is tightened without twisting hose.—AVIATION, Aug., '44.

Centrifugally cast aircraft parts:
(top right) Propeller rear hub cone; (bottom right) Landing gear shock absorber packing nuts; (left) Bushings for controllable pitch propellers as cast, semi-finished, and finished.
Centrifugal Castings of Wear-resisting Ampco Metal
save machining time and costs —save metal—cut scrap losses

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Centrifugal casting further enhances the extra endurances, the extra margin of safety obtained with Ampco Metal parts. Investigate! A letter or card will bring the services of a competent field engineer. Field offices in principal cities. AA-4

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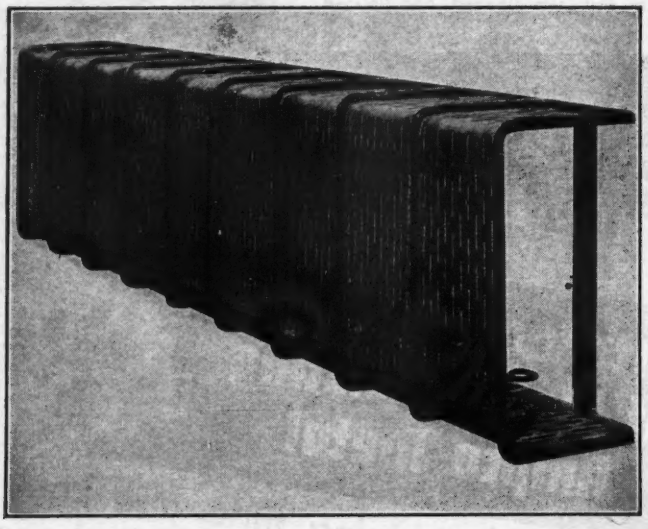

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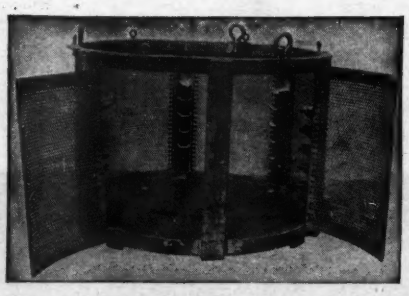


Lubrication System Kits.....74

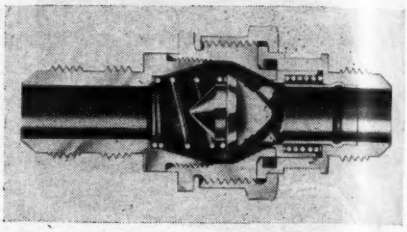
Lincoln Engineering Co., St. Louis, announces that its "Centro-Matic" lubricating systems are now available in complete kits, ready for installation on all types of standard punch presses. Kits contain injectors, pump, and necessary tubing brackets, bolts and fittings.—AVIATION, Aug., '44.

Explosive Rivet 75

Rivet of explosive type that fits itself to hole has been developed by Du Pont & Co., Wilmington, Del. Rivet is expanded from within along substantially its entire shank, instead of at end of shank. New rivets will be available in diameters of 5/32 and 3/16 in.—AVIATION, Aug., '44.

Self-Sealing Coupling.....76

New self-sealing coupling is designed to allow disconnection and reconnection of hydraulic or other lines without loss of fluid or inclusion of air. Maker is Aeroquip Corp., Jackson, Mich. Seal is effected by O-ring embedded in recess of body. One half can be provided with



detachable mounting flange. On connecting coupling halves, protruding portion of left half makes contact with sleeve of other body. Simultaneously all air is expelled between mating part of halves. Further movement of union nut moves valves until position is reached allowing free passage of fluid.—AVIATION, Aug., '44.

Electronic Relay 77

New electronic relay for amplifying very limited current transmitted by delicate control contacts or high resistance circuits is announced by General Electric Co., Schenectady (Electrical Control Div.). Operated via any material having a resistance from 0 to 500,000 ohms, or greater, new relay is suitable for controlling liquid levels in tanks and boilers, sorting metallic parts by size, and as a limit switch requiring extremely light pressure. Unit consists of standard type electronic tube, supply transformer, and electromagnetic relay, with mounting in weather-resistant enclosure. In operation, electromagnetic relay is kept energized as long as controls connected to input grid circuit of tube remain open. Built-in time-delay feature is to prevent chattering when contacts in input circuit are momentarily closed, and contact arrangement on relay is to permit device to be used either to make or break load circuit when actuating contacts to input circuit are closed.—AVIATION, Aug., '44.

Aircraft Pipe Thread Gage.....78

New line of gages for checking aircraft pipe threads has been developed by Pratt & Whitney, Div. Niles, Bement-Pond Co., West Hartford, Conn. Double end gage checks lead, form taper, and diameter of internal threads; and plain taper-plug gage checks taper roundness and minor dia. Set of two special ANPT tri-roll gages check internal threads. First is tri-roll gage which checks lead, form,

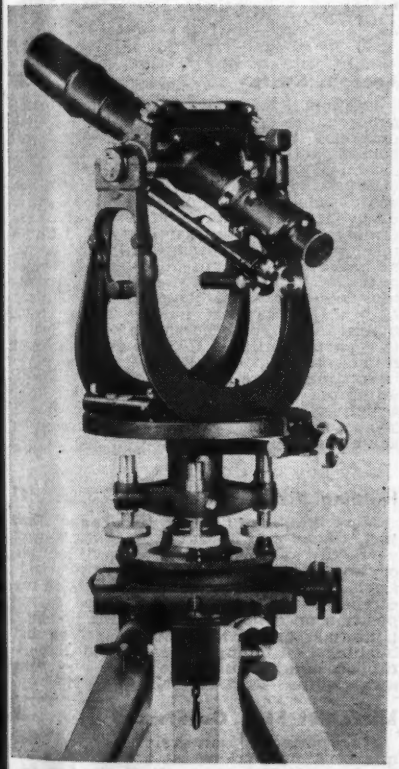
taper, and pitch dia. Second is plain taper tri-roll gage for checking taper and dia. of threads at crest. Unit has stepped plunger and three steps on bottom of gage for classifying thread. Setting plug is supplied with each.—AVIATION, Aug., '44.

High Shear Fasteners 79

Pheoll Mfg. Co., Chicago, has been appointed prime licensee by North American Aviation for manufacture of new "Hi-Shear" rivets developed by latter. Rivet consists of two parts—pin and collar. Pin is made of alloy steel, heat treated to minimum tensile strength of 125,000 psi. and cadmium plated. Collar is A17ST aluminum alloy anodized. Essentially threadless bolts, units are installed with riveting equipment—a one-piece article with conical bore in end which swages collar into grooved pin end. This special set may be used as part of bucking bar or may be fitted to riveting gun. Operation: After pin is inserted, bucking bar is placed against pin head and rivet collar slipped over pin end. Then set is placed over collar and as pressure is applied, soft collar is forced into groove, while ring of waste material, pinched off when collar is formed into a conical head, is expelled through waste part of set.—AVIATION, Aug., '44.

Aircraft Jig Collimator 80

New jig Collimator is a simplified surveying transit used in construction of master tooling jigs for aircraft sub-assemblies, designed to replace network of piano wires usually necessary as horizontal and vertical guides. Transit con-



sists of simple center, single horizontal clamp and tangent, stable one-piece standard with spirit levels and telescope with fine cross wires, sensitive spirit level, and clamp and tangent motion. Increased accuracy and time saving is reported. Maker is **C. L. Berger & Sons**, Boston.—AVIATION, Aug., '44.

Condenser Tester 81

Lanagan & Hoke, Philadelphia, announces Model 112B condenser tester, equipped with 4 in. D'Arsonval movement meter, plainly marked in colors, with a single switch for all tests. Line voltage can be adjusted to suit conditions. Pilot light acts as "off-on" indicator.—AVIATION, Aug., '44.

Anchor Nut 82

Nutt-Shel Co., Los Angeles, announces new type, light-weight, self-locking anchor nuts. Illustrated is unit consisting

of fiber self-locking device and steel nut. Line includes plain and self-locking retainers and single-lug, two-lug bolt and nut anchor plates. Specially designed types are also available.—AVIATION, Aug., '44.

Tail Wheel Connector Spring.....83

Scott Aviation Co., Lancaster, N. Y., announces new type universal connector spring for tail wheel assemblies. Adjustable in length to fit all makes of aircraft, it incorporates a universal joint, and adjustable feature enables user to secure proper tension. Has locked connection at one end.—AVIATION, Aug., '44.

Glareless Glass 84

American Optical Co., Southbridge, Mass., announces a new surface treatment which is reported to reduce reflections on large areas of glass, plastics, and varnished wood.—AVIATION, Aug., '44.

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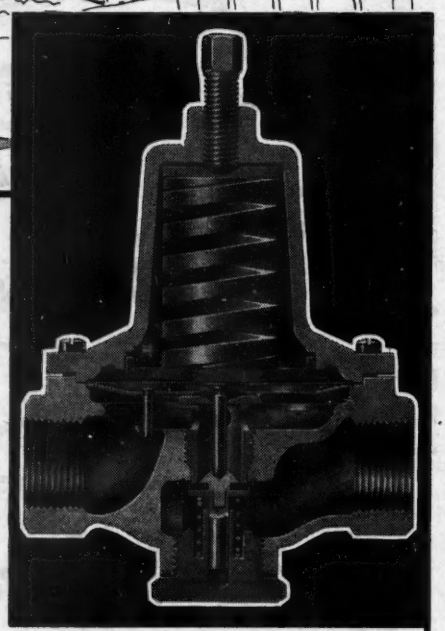

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...or other air-actuated mechanism

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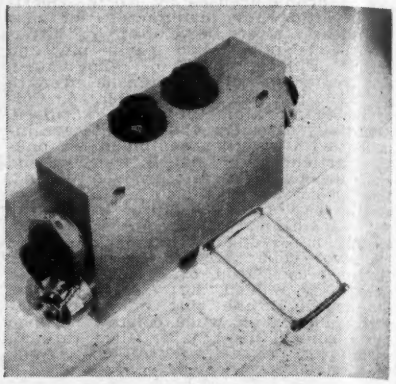
Get the facts! Write for Catalog 400. C. A. Norgren Co., Denver 9, Colorado.

Norgren

Hydraulic Lock Valve.....85

Designed for installation in aircraft to protect machine gun turrets, landing gear, and other vital controls against operation due to leakage, new light weight hydraulic lock valves have been devised by **Adel Precision Products**, Burbank, Calif., to lock fluid in cylinders or



hydraulic motors until directional control valve is operated. Automatic in operation, valves hydraulically lock cylinder and are opened by pressure released by selector valve. Thermal relief valve is is incorporated in each lock valve cylinder port to bleed off excess pressure at from 1,200 to 2,000 psi. Operation range is from —65 deg. F. to +160 deg. F. Type D12940, illustrated, weighs 1.18 lb., measures 4 x 2 7/16 x 1¼ in.—**AVIATION, Aug., '44.**

Aneroid Switch 86

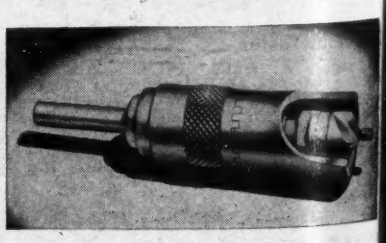
Designed for close control of engine superchargers, class 9315 aneroid switch made by **Square D Co.**, Detroit, is reported to offer possibilities involving electrical control responsive to altitude changes. Unit is comprised of precision switch mechanism actuated by sensitive diaphragm or bellows of evacuated and temperature compensated type. Entire mechanism is mounted within a die-cast, anodized, aluminum housing provided with gasketed cover. Manifold or atmospheric pressure connection is through ⅛-in. IPS tapped hole. Three point mount is stated to be shock proof. Switch is reported suitable for use over range of minus 65 deg. F. to plus 160 deg. F. Operating range is up to 35,000 ft., with minimum differential of 1,000 ft. Net weight is 24 oz. At 28v. d.c., switch will handle up to 25 amp. in-rush current on solenoids.—**AVIATION, Aug., '44.**

Holding Fixture 87

New holding fixture by **Zagar Tool, Inc.**, Cleveland, is stated to work as well vertically as horizontally and without use of angle plates. Body has two right-angled faces milled with key slots in two directions on each face, adapted to any position on drill press or milling machine. Unit has tapped holes for mounting drill bushings. Cutting oil is forced through tapped hole to lubricate work and wash away chips.—**AVIATION, Aug., '44.**

Micro-Set Stop Countersink.....88

To permit countersinking in close quarters, new micro-set stop countersink is announced by **Aircraft Tools**, Los Angeles. Cutaway skirt feature is to enable countersinking in corners, next to joints, on plate nuts and other close spots. Incorporated are split collet type shaft, full ball thrust bearing, positive sight adjustment in increments of .002 in., and lock spring in sight adjusting sleeve—**AVIATION, Aug., '44.**



Induction Heating Unit.....89

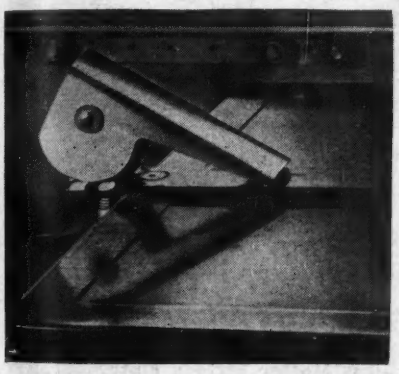
New 25 KW Megatherm induction heating unit adapted to high speed induction surface hardening of such parts as bearing surfaces, cam faces, and gear tooth contours (also to field of brazing and silver soldering) has been introduced by **Industrial Electronics Div., Federal Telephone & Radio Corp.**, Newark, N. J. Equipment, using frequencies between 2-5 million cycles per second, is designed for effective and speedy heating of brass, copper, and aluminum alloy pieces, as well as usual steel parts. Heating fixture is coil of from one to five turns which can be readily constructed from standard copper tubing. Unit is designed to deliver 25 kw. continuously at frequencies adjustable within the 2-5 million cycle range. Power factor of Megatherm is stated to be 95 percent.—**AVIATION, Aug., '44.**

Retractable Tubing 90

"Wiremold" retractable tubing has been developed to meet industrial requirements for a portable duct connection for cold or heated air. Made of light weight fabric, 15 ft. length when retracted can be stowed in 1-ft. container. Standard inside dia. are 4, 6, 8, 10, and 12 in.; lengths are 2 to 50 ft.; and ratio of retractability is 15 to 1 for standard weight material. Temperature of heated air: To 300 deg. F. Many types of flexible material can be used, from light weight cotton to heavy canvas duck, impregnated if desired, and tubing is stated to be useful on aircraft engine preheaters. Maker is **Wiremold Co.**, Hartford, Conn.—**AVIATION, Aug., '44.**

Battery Hold-Down Clamp.....91

Developed by **The Paul Henry Co.**, Los Angeles, new battery hold-down clamp was developed to speed and simplify



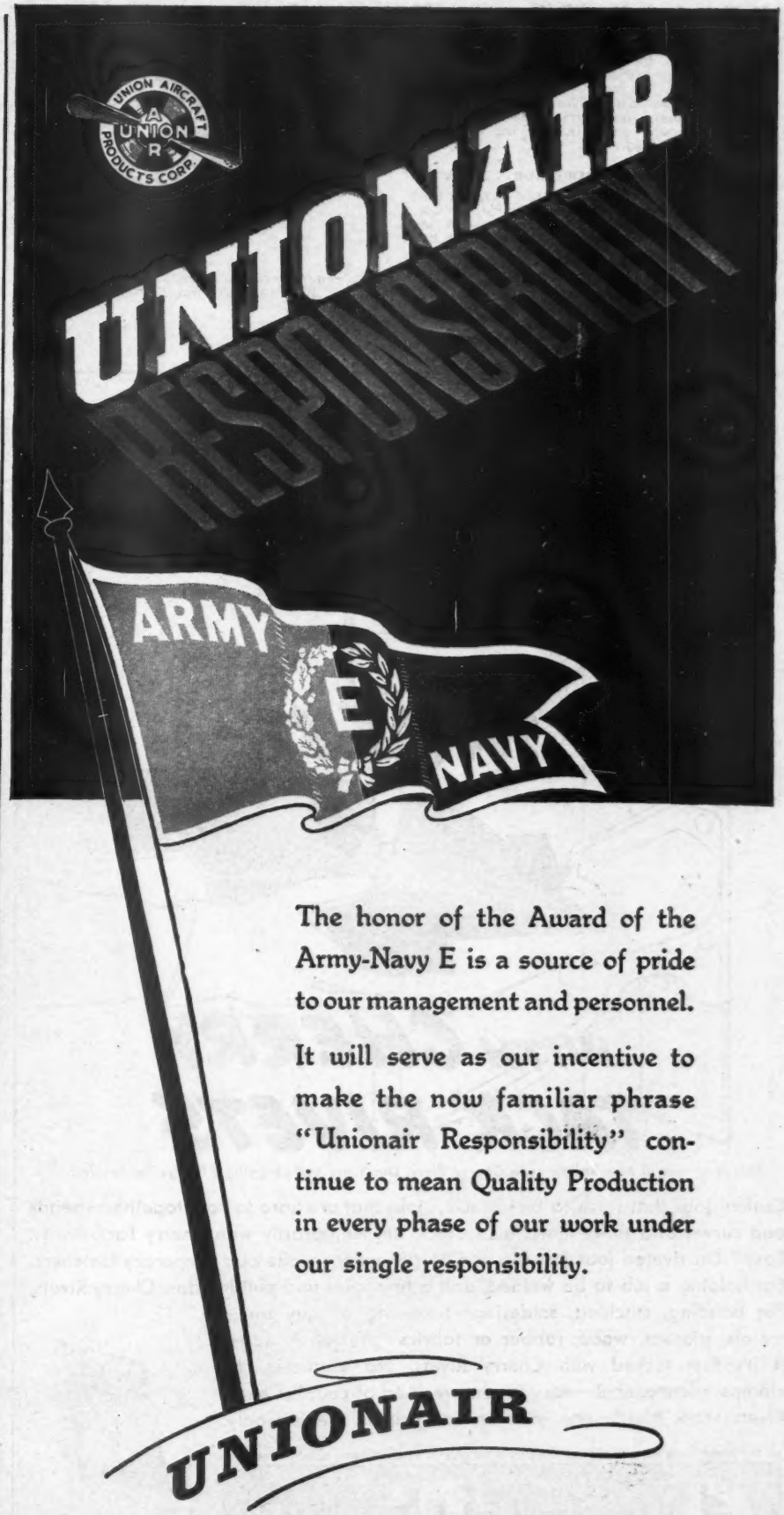
removal of batteries. Clamp replaces usual wing nuts. Cam action is stated to eliminate safety wiring and provide positive locking action.—**AVIATION, Aug., '44.**

Weld Timer-Contactor Unit.....92

Combination timer-contactor package units to provide automatic electronic control for resistance welders are announced by **Weltronic Co.**, Detroit. New units may be used with new machines or to convert manually or cam-timed welders. Designed to provide flexibility of use, universal wall or floor mounting cabinet houses any combination of interchangeable "Nema" type timers, with choice of "Ignatron" or mechanical type contactors. Plug-in control panels permit change from any type control to another for inspection or conversion. Cabinet is 16½ in. wide by 33 in. high and 10½ in. deep.—**AVIATION, Aug., '44.**

Hydraulic Pump 93

Pesco Products Co., Cleveland, announces new hand operated hydraulic pump with double acting differential piston. Maximum displacement per complete cycle is 1.5 in. and rated capacity 0.125 gpm at 30 cycles per minute with 1,500 psi. discharge pressure. Operating pressure is 1,500 psi with 53 lb. force on handle (which has 57½ deg. total movement). Lubrication is by fluid passing through pump. Packing is suitable for operation with mineral oil. Weight is 2.4 lb.—**AVIATION, Aug., '44.**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The honor of the Award of the Army-Navy E is a source of pride to our management and personnel.
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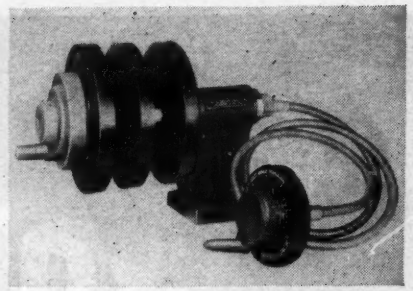
Conduit Fittings—Junction Boxes
UNION AIRCRAFT PRODUCTS CORP. NEW YORK

Multiple Angle Hand Drill.....94

Designed with hinged handle, "Joic" hand drill made by **Joyce & Associates**, Los Angeles, is built to permit operations in restricted areas without loss of pressure. Unit swivels on drive gear to various angles and locks tightly in seven different positions. Drill is 8½ in. long, weighs 18 oz., and has ¼ in. chuck.—AVIATION, Aug., '44.

Variable Speed Transmission.....95

Reporting simplified remote control and universal mounting, **American Pulley Co.**, Philadelphia, announces new variable-speed transmission for drives up to 1 hp. Remote control is through compact flexible shaft making it possible to mount unit anywhere in or on machine, vertically, horizontally, or in any intervening position. V-belts are used to provide



stepless control of speed through 3-to-1 ratio. Flanges are plastic.—AVIATION, Aug., '44.

Foot Control for Burr-Remover.....96

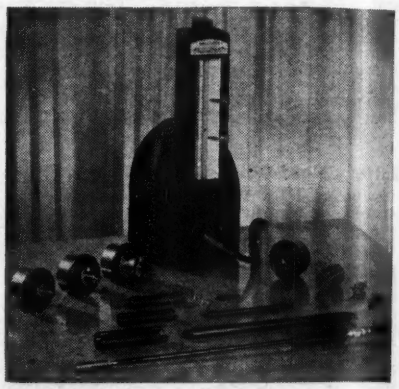
Foot control unit is offered to convert drill press into burr remover by leaving operators' hands free. Maker is **Nobur Mfg. Co.**, Los Angeles.—AVIATION, Aug., '44.

Round Tool Bits.....97

Bits of Stellite 98M2 or Stellite Star J-metal alloy, are now furnished by **Haynes Stellite Co.**, Kokomo, Ind. They are furnished centerless-ground to tolerances of plus 0.000 and minus 1.002 in. on diameter, and plus or minus 1/16 in. on length. Bits are used on turning or boring operations, or they can be ground into drills or reamers.—AVIATION, Aug., '44.

Air Gage Spindle Standards.....98

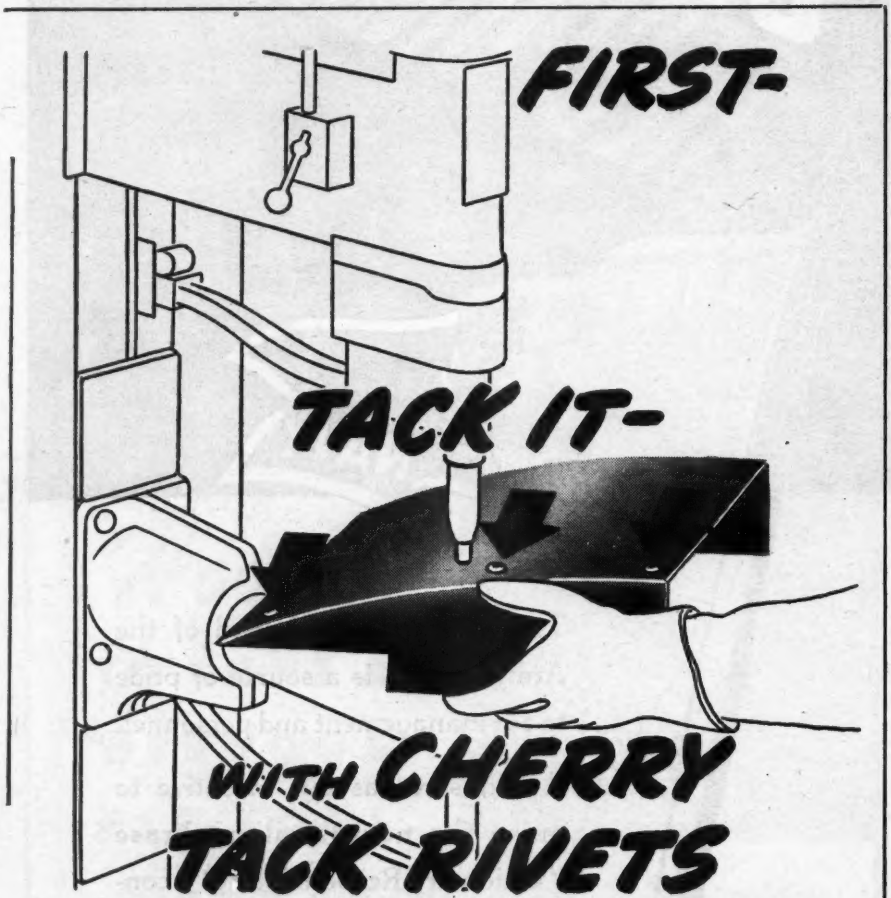
Type and size standards of air gage spindles for dimensional inspection of internal diameters and bores have been established by **The Sheffield Corp.**, Dayton, Ohio. Standards have been set up on "Precisionaire" spindles for checking either "through" or "blind" holes from .300 to 1.734 in., with tolerances from .005 in. to 50 millionths and less. All spindles within certain size ranges may be used on "Precisionaire" instruments for corresponding tolerance range. Additional standards are being prepared.



Four types of standard assemblies are available. Types "A" or "A-1" are used where gage is presented to work, and consists of spindle, extension shaft, handle, and hose. Type "A" is designed for checking "through" holes and type "A-1" for blind and counterbored holes. Types "B" or 'B-1" are used where work is presented to gage and consists of spindle and adapter.—AVIATION, Aug., '44.

Glass Master Surface Plate.....99

Geo. Scherr Co., New York City, announces "Opti-Flat", optically polished glass master surface plate, flat to an accuracy of 50 millionths. Plates, resistant to abrasion, are 2 in. thick for 12-in. size and 3 in. thick for 16-in. size —AVIATION, Aug., '44.



This is a special new hollow type Cherry Rivet. Don't use self-plugging Cherrys for tacking.

Critical jobs that have to be just so . . . jobs that are hard to hold together—bends and curves and shifty materials . . . tack 'em temporarily with Cherry Tack Rivets. Easy? On riveted jobs just flip in Cherrys every so often as temporary fasteners. For holding a job to be welded, drill a few holes and pull in a few Cherry Rivets. For bonding, stitching, soldering—fastening of any sort—metals, plastics, wood, rubber or fabrics—the job is easier if it's first tacked with Cherry Rivets. No obstacles, no clamps—economical—easy to remove. And of course Cherry Rivets work blind—one man on one side of the job only.

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Presenting
LOCKHEED'S
Constellation
A STORY OF
NEW WORLD STANDARDS
IN AIR TRANSPORTATION

1783
1786
1852
1903
1906
1909

The epic of flight, of man's resolute will to win the air, is still in the making.

Yet when the story is entered in the chronicles of the future,

the Constellation will signal the end of one chapter and the beginning of another.

It will be recorded then: the routine transcontinental flight of less than seven hours,

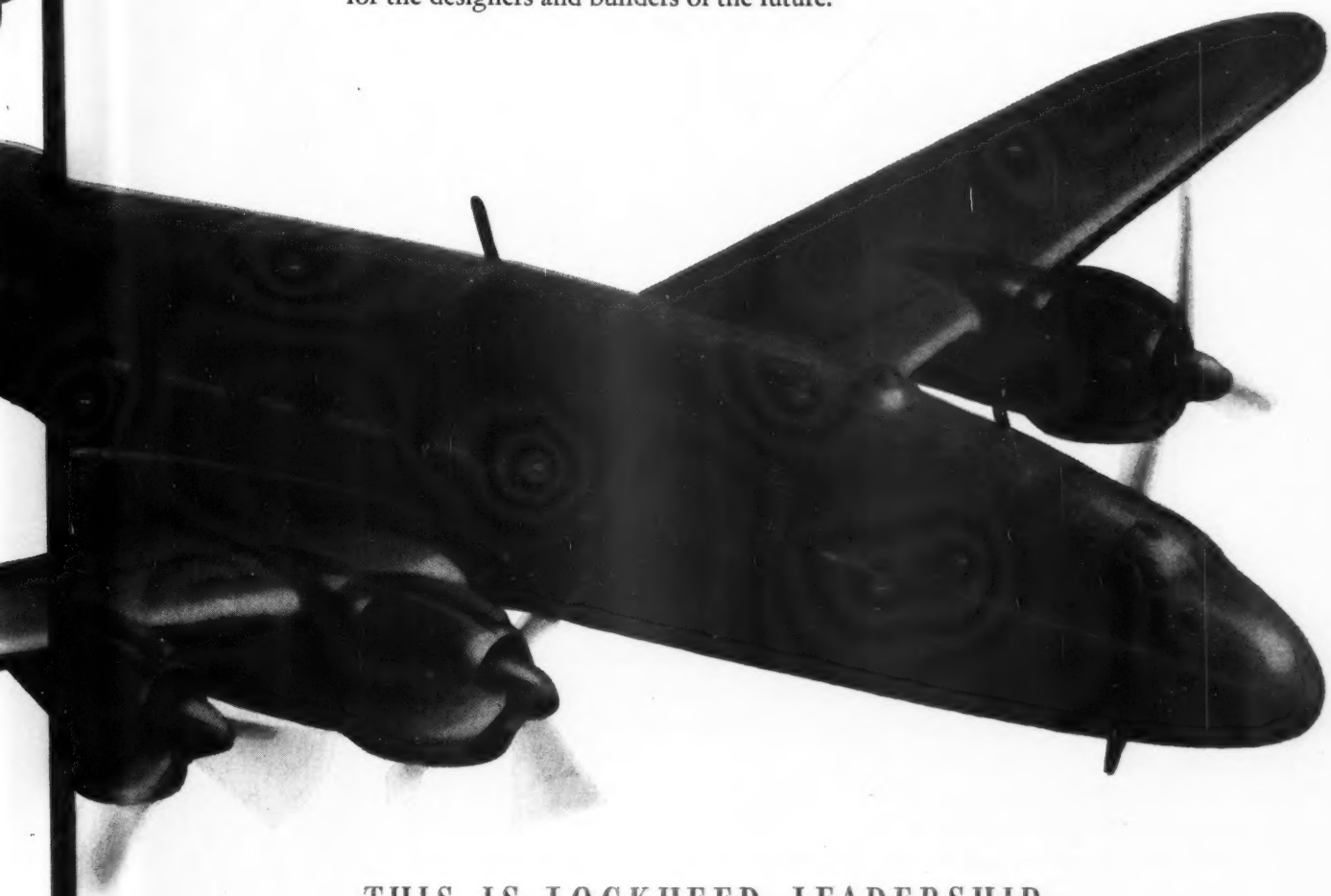
the precious cargoes swift to the war fronts, the superior speed and rate of climb and load capacity.

All these will be revealed and it will be evident that in the year 1944

the Constellation brought to full expression the combined triumphs of the past,

establishing new standards in air transportation and setting a true course

for the designers and builders of the future.



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The Constellation

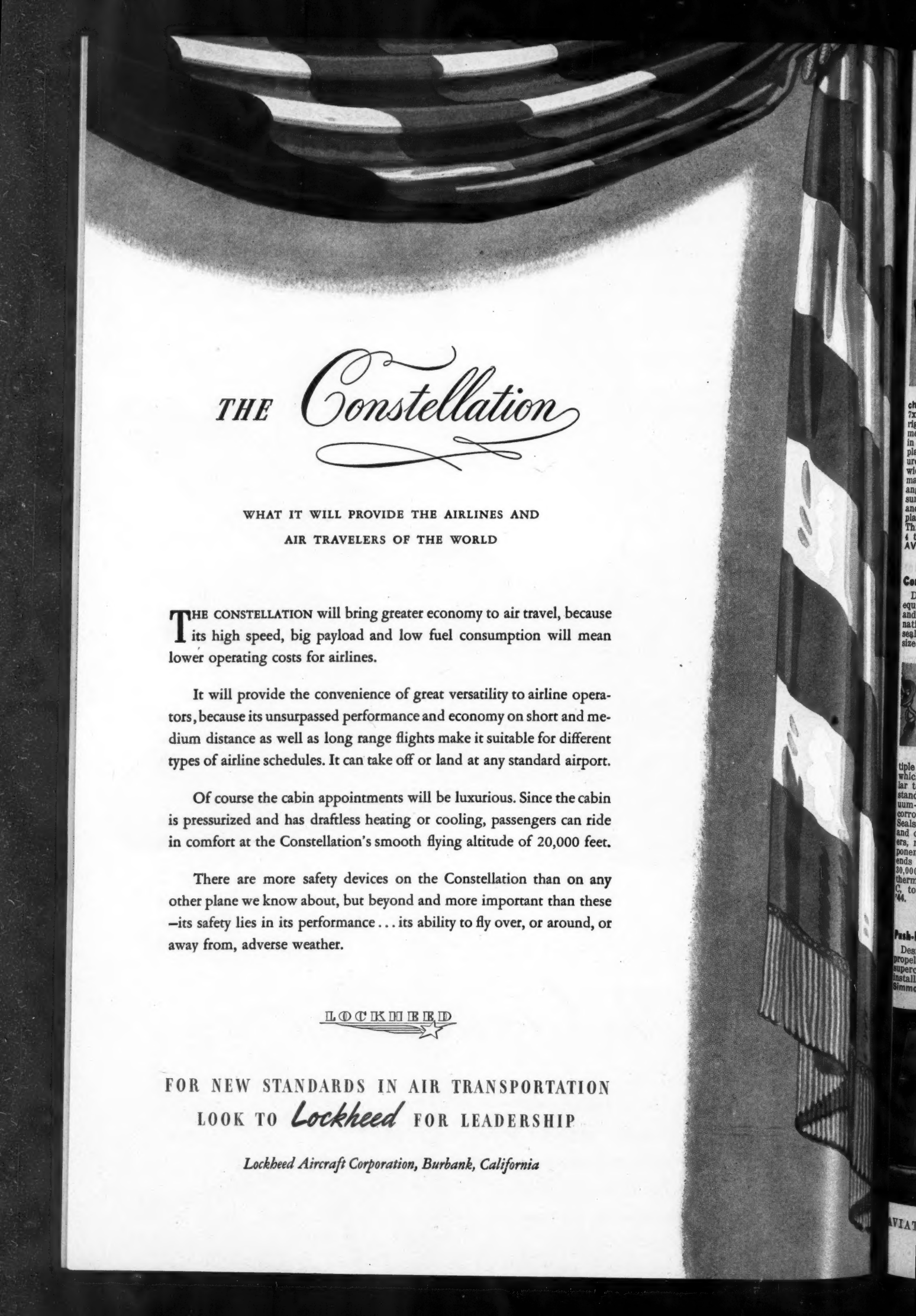
Highest speed of any transport—cruising at more than 300 m.p.h.

Longest range of any transport—non-stop coast to coast

Biggest load-carrying capacity of any transport—64 passengers, crew and cargo

Greatest rate of climb of any transport—one-third mile a minute on four engines

AND *these performance factors make the Constellation the safest of any transport.*



THE *Constellation*

WHAT IT WILL PROVIDE THE AIRLINES AND
AIR TRAVELERS OF THE WORLD

THE CONSTELLATION will bring greater economy to air travel, because its high speed, big payload and low fuel consumption will mean lower operating costs for airlines.

It will provide the convenience of great versatility to airline operators, because its unsurpassed performance and economy on short and medium distance as well as long range flights make it suitable for different types of airline schedules. It can take off or land at any standard airport.

Of course the cabin appointments will be luxurious. Since the cabin is pressurized and has draftless heating or cooling, passengers can ride in comfort at the Constellation's smooth flying altitude of 20,000 feet.

There are more safety devices on the Constellation than on any other plane we know about, but beyond and more important than these —its safety lies in its performance . . . its ability to fly over, or around, or away from, adverse weather.

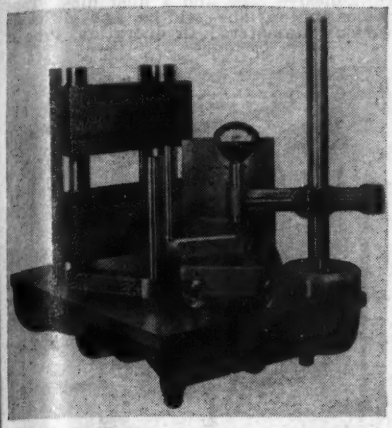
LOCKHEED

FOR NEW STANDARDS IN AIR TRANSPORTATION
LOOK TO *Lockheed* FOR LEADERSHIP

Lockheed Aircraft Corporation, Burbank, California

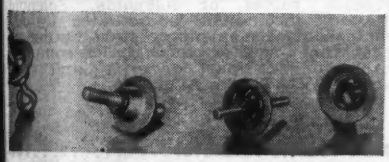
Angle Check Instrument.....100

Designed for wide range of angle checking, three-part inspection combination is announced by **Thomas Tool & Machine Co.**, Pontiac, Mich. It features 7x12x12-in. sine angle square to permit right and left hand horizontal angle measurement up to 75 deg. When used in conjunction with surface plate angle plate, vertical right and left hand measurements can be attained, together with wide range of projection checking. It may also be used as small surface plate angle plate. Second unit is heavy type surface plate angle plate with hardened and ground cylindrical posts and cross plates. Posts are hollow and ventilated. Third unit is a utility tri-square in sizes 4 to 16 in. with solid cylindrical post.—**AVIATION, Aug., '44.**



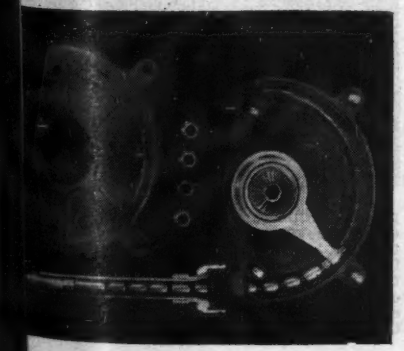
Communication Seals 101

Designed for sealing communication equipment against weather, insects, dust, and other hazards, **Sperti, Inc.**, Cincinnati, states it has perfected "Hermetic" seals, available in special shapes and sizes either as single terminals or multiple headers. Made of glass and a metal which has an expansion coefficient similar to glass (said to be capable of withstanding severe thermal shock) a vacuum-tight bond is created that resists corrosion, either atmospheric or liquid. Seals are attached by soldering to plates and cases, and to transformers, condensers, relays and miscellaneous radio components, by means of small eyelets on ends of shaft. Leakage resistance of 30,000 ohms, minimum, is reported and thermal operating range of from —70 deg. C. to +200 deg. C.—**AVIATION, Aug., '44.**



Push-Pull Control Adjunct 102

Designed for use in connection with propeller governors, carburetor air and supercharger controls, and other similar installations, "Radian" unit made by **Simmonds Aerocessories**, New York City, is reported to provide positive rotary-motion action from push-pull operation. It weighs approximately 12 oz. There are three basic parts: Housing, lever-arm, and bushing. Housing contains track of linkage path, while lever-arm carries out angular travel and bushing transfers angular travel to shaft to be actuated.—**AVIATION, Aug., '44.**



Electrical Connectors 103

Designed to provide a water seal for cable ends, "Hysealugs", electrical connectors, are made from silverplated copper. Barrel is indented onto conductor, while shroud is compressed over insulation to form water tight seal. Installation is made with "Hypress" and dual die. Terminals are available for cables from No. 4 to 2000 MCM. Manufacturer is **Burndy Engineering Co.**, New York.—**AVIATION, Aug., '44.**

Welding Temperature Calculator..104

New calculator designed for determining welding, preheating, and interpass temperatures of steels in those cases where experience indicates need for preheating, is announced by **Lincoln Electric Co.**, Cleveland. Calculator, of 6¼-in. dia., consists of four movable sections of heavy cardboard stock. — **AVIATION, Aug., '44.**

Tail Wheel Jack.....105

To lift tail wheel to flight level for checking instruments, **Phillips Pump & Tank Co.**, Cincinnati, has designed Universal model airplane tail and leveling jack which has a maximum lift of 70 in. Jack is designed to enter under tire while resting on ground, raising plane from this point rather than from point under fuselage.—**AVIATION, Aug., '44.**

B-29 Fliers
wear Ray-Bans over Japan
The 20th Air Force —which sent its B-29 Superfortresses over Japan on June 15, for the first publicly-announced mission of these giants of the air—is manned by selected, experienced personnel. 700 men of this Force required visual correction. Before they left the U. S., these men were equipped with Bausch & Lomb Ray-Ban Glasses, specially computed and individually fabricated to provide each with keenest, cool, comfortable correction and protection.
High above the clouds, on the surface of the sea, on beachhead and battle front—wherever glare is a hazard—American fighting men are wearing Ray-Bans. After Victory, the safe scientific glare protection of Ray-Ban will be available to more millions of outdoor enthusiasts.
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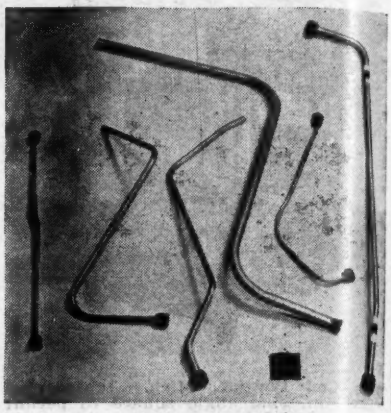
Aircraft Tubing Sealer.....106

Developed to enable automatic sealing of aircraft tubing, new machine made by **T. R. I. Engineering Co.**, Los Angeles, employs seals of pressure sensitive fabric adhesive tape and a fiber disk. Tape comes in various widths and disks in various diameters. In operation, tube is



inserted in guide and slight pressure on micro-switch actuates folding and pressure applying device around tube or nut, tape having been automatically cut and disk centered therein. Seals are stated to be puncture and tamper proof. Machines, made in three sizes, handle plain and beaded tubes and tubes with nuts. Power requirements: 24v. d.c., compressed air 30 psi., motor 1/20 hp.—**AVIATION, Aug., '44.**

Multi-Contact Timer 107

New multi-contact timer for remote control is announced by **R. W. Cramer Co.**, Centerbrook, Conn. It is used to control a series of machine operations in definite order; to automatically reverse or alternate in operation a group of motors, machines, or devices, or to operate in predetermined sequence a series of signals, valves, or solenoids. Solenoid starting mechanism is actuated by remote control momentary start button so that timer will go through its complete cycle, or any part of cycle, and then stop.—**AVIATION, Aug., '44.**

New Plastic Insulator.....108

Westinghouse Electric & Manufacturing Co., Pittsburgh, has released information on "Fosterite," a waterproof plastic designed to seal radar and radio parts against moisture and lengthen life of communications equipment. In the tropics, where humidity is high, moisture seepage into electrical equipment, causing short circuits, has been a great problem. New plastic was devised to solve this difficulty. Applied in fluid form,

product fills smallest spaces to insure complete watertightness. It is stated that coatings may be applied without fear of cracks. Photo shows plastic-treated control transformer operating efficiently, as indicated by light in bulb, even though unit is emersed in water. Company has also released information

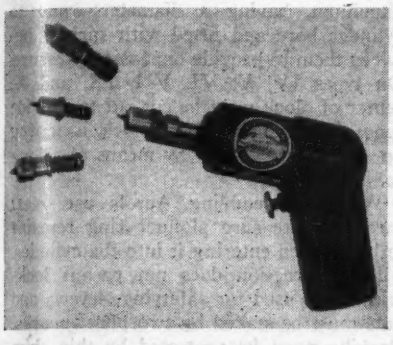
on performing, a method to mold plastics into complex shapes; on a new system for stretching hot plastics into intricate forms; and on Micarta 444, a substitute shellac.—AVIATION, Aug., '44.

Electrical Tachometer 109

New electrical tachometer designed for all speed measuring requirements is being introduced by **R. B. Brigham Co.**, Toledo. Unit has no brushes, commutators, or gears. Special calibrations on scale of indicator enable direct readings in miles per hour, revolutions per minute, feet per minute, frames per second, gallons per hour, or pounds per minute. Direct scale readings up to 50,000 rpm. are possible.—AVIATION, Aug., '44.

Fastener Tool 110

A new pneumatic tool has been developed by **Smith-Johnson Corp.**, Los Angeles, to insert and remove sheet metal skin fasteners and skin clamps. Known as Model C Airplyer, new tool is stated



to speed rivet hole alignment, decrease operator fatigue, and provide maximum safety. Tool operates on 50 to 175 lb. air pressure, with pressure ratio of 1-to-1. It weighs 1 lb 2 oz.—AVIATION, Aug., '44.

Aerols Care

(*Continued from page* 169)

parts should be removed and replaced. Very careful inspection should also be made of attachments connecting Aerol to plane.

Hundred-hour check should preferably be made with weight of airplane removed from wheels.

In addition to daily and 25-hr. check, all landing gear fittings should be checked and parts shown in Fig. 1, 2, & 3 lubricated, using high-melting-point grease, A.C. Specification 3560.

Storage

In storage, Aerols should be compressed to shortest position and be placed with air valve uppermost. Since packing depreciates rapidly during storage, when inflated, units should be deflated and stored without fluid or packing if kept for long periods as spare parts. Non-acid-forming anti-rust compound should be used on all parts subject to corrosion.

When restoring for service, clean piston tube thoroughly, release air by lifting tail of airplane, and coat piston lightly with fluid. Loosen gland nut several turns and move piston up and down several times to work oil into packing gland. Tighten gland nut and inflate to proper length.

It is understood that efficiency of Aerols depends to a great extent upon the cor-

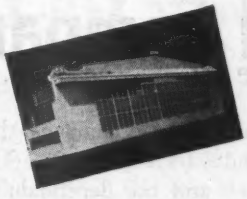
LST SHIPS

ARE WELDED CONSTRUCTION

To keep pace with war's stepped-up tempo, International Steel Company technicians and shopmen are daily matching wits with new production problems and schedules. They are pitting their sharpened skills against the need for faster-built, better-built LST ships, for invasion docks, trestles and bridges.

Only when peace comes will the whole story of this tremendous effort be told. It will be told in faster, lower-cost production and in new prefabrication methods. Yes, it will take less time after the war to deliver to you complete hangars, hangar doors and other International Steel products —and they'll be better and lower priced because of this war-production experience.

"PACKAGED" HANGARS FOR POST-WAR



New low costs . . . Rapid assembly with unskilled labor . . . Simple expansion, alteration or removal with 100% salvage of parts.

In sizes for a single plane, or hundreds of planes, the new prefabricated steel hangars developed by International Steel engineers have distinct advantages.

A request on your letterhead will bring you full information about these and other postwar improvements in International building products. Perhaps we have the best answer to some of your postwar problems.

International STEEL CO.

ALL-STEEL HANGARS
MASONRY-STEEL HANGARS
HANGAR DOORS
STRUCTURAL STEEL

1703 EDGAR STREET
Evansville 7, Indiana

rect working condition of the other components of the gear, and for this reason these parts should be overhauled or serviced at the same periods that the work is performed on Aerols. Disassembly should be undertaken with reference to Fig. 4 as a guide to construction.

Remove Aerol from airplane, *release all air pressure,* remove filler plug assembly, and drain by holding at 45 deg. and moving piston through full stroke several times to eject fluid. If torque arms are fitted, remove bolt which connects lower arm (21) to body. And if gland nut (22) is used, cut lock wire (7) and remove lock screw from gland nut. Turn gland nut completely off or out of cylinder.

Pull piston assembly completely out of cylinder. If follower nuts (26) are used, they must be removed before piston assembly can be drawn out of cylinder. Remove lock nuts, etc., from piston and unscrew piston head from end of piston. Slip all parts off upper end of piston. Where plunger tube (17) is fitted, remove all lock screws, gaskets, etc., and unscrew plunger tube. Then snap off plunger head ring (31).

Inspect all welded parts for evidence of cracks and replace entire part if defective. If plating on outer wall of piston is worn or deteriorated, piston must be replated. Then follow this procedure:

(a) Grind piston to remove all signs of corrosion or damage, removing not more than .002 in. on radius or .004 in. on dia.

(b) Have piston re-chrome plated.

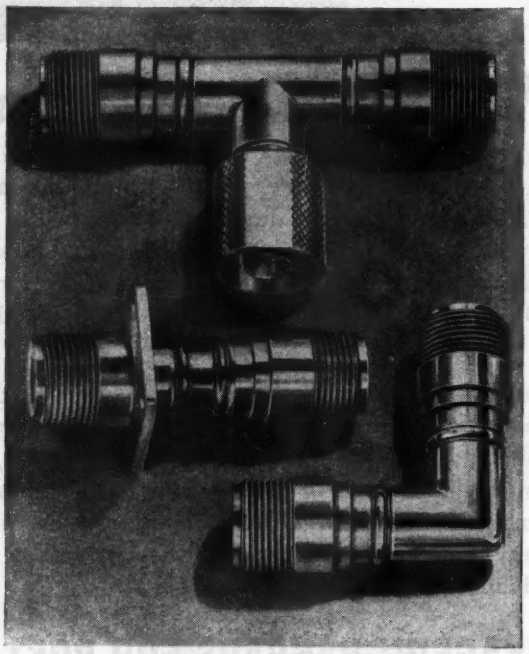
(c) Regrind to correct size.

If packing is no longer serviceable it must be replaced; in any event, it should not be used for more than a year. Copper gaskets should be replaced if they show any signs of damage which might cause leakage under pressure.

Inner wall of cylinder must be inspected for corrosion or scoring. To make this inspection, flash a light inside cylinder. Slight scoring or corrosion may be polished until removed. This is done by using two half cylinders, of wood or aluminum, having a diameter equal to cylinder bore and fitted with springs between them to provide expansion pressure. On types IV, V, VI, VII, IX, and X, center of block must be cut out to provide room for plunger tube. Block is moved up and down cylinder by means of a long rod.

When reassembling Aerols use great care to make sure plunger ring remains in head when entering it into the cylinder.

If construction does not permit lockwire to be used for safetying, screws and nuts must be staked by two punch marks. Packing must be protected by thin shim during insertion, as shown in Fig. 8.



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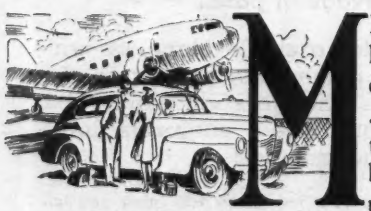

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Boeing Wind Tunnel

(*Continued from page* 149)

For cooling purposes, air is taken into and exhausted from the tunnel through a pagoda-like interchanger tower on top of the building. At extreme high speed operation, when the fan is operating at its maximum of 494 rpm. and air is making the 450-ft. circuit in less than 2 sec., compression and friction heat would probably reach to over 450 deg. F. within 5 min. if no provision was made for cooling. By scooping off the top 11 percent of the air and replacing it with fresh air from outside, this temperature is reduced to a maximum of 120 deg., and three complete changes of air occur each minute.

Extending across each corner of the tunnel are vane cascades to turn the air around the corners with a minimum of drag and disturbance. These vanes are hollow and are sprayed inside with water to help in reducing the temperature of the air. Surfaces of the vanes in two of the corners are coated with grease to collect dust.

Power to drive the fan is furnished by a 18,000-hp. electric motor (built by Westinghouse especially for this installation) which operates at a constant speed of 514 rpm. It is started by another motor of 450 hp. which brings the main motor to its top speed before power is applied to the main motor.

The driving motor was designed also

to be used as the power source for the second tunnel, sometime in the future. The motor shaft has a double extension so that a magnetic coupling and fan shaft attached to the other side of it will lead to the site of the future tunnel.

The main motor is connected to the fan by a magnetic coupling and a 10-ton steel shaft 37 ft. long. Shaft, propeller hub, bearings, electric power transformers, and much of the other electrical apparatus for the tunnel, were also made by Westinghouse, and the magnetic coupling and its controls were supplied by the Dynamatic Corp. It is necessary to operate the fan at various speeds during tests, and since the motor has a constant speed, the magnetic coupling is necessary.

Located between the motor and the fan shaft, the coupling consists of two revolving metal members, separated by an air gap and having no mechanical connection with each other. The ring on the fan side is magnetized so that it is pulled around by the other ring in the same direction, thus transferring power from the motor to the fan shaft.

By increasing the amount of current passed through the electromagnet, pull is increased and more speed is attained. When propeller speed is reduced the extra power is converted into heat in the coupling and is removed by water flowing through a surrounding jacket.

Another feature of the electrical installation is a smaller magnetic coupling driven by an exciter motor and which, in turn, operates an alternator that supplies variable frequency power to the small electric motors driving propellers on the model airplane being tested. The amount of power supplied to the model can be increased or decreased by controlling the speed of the rotor on the small magnetic coupling.

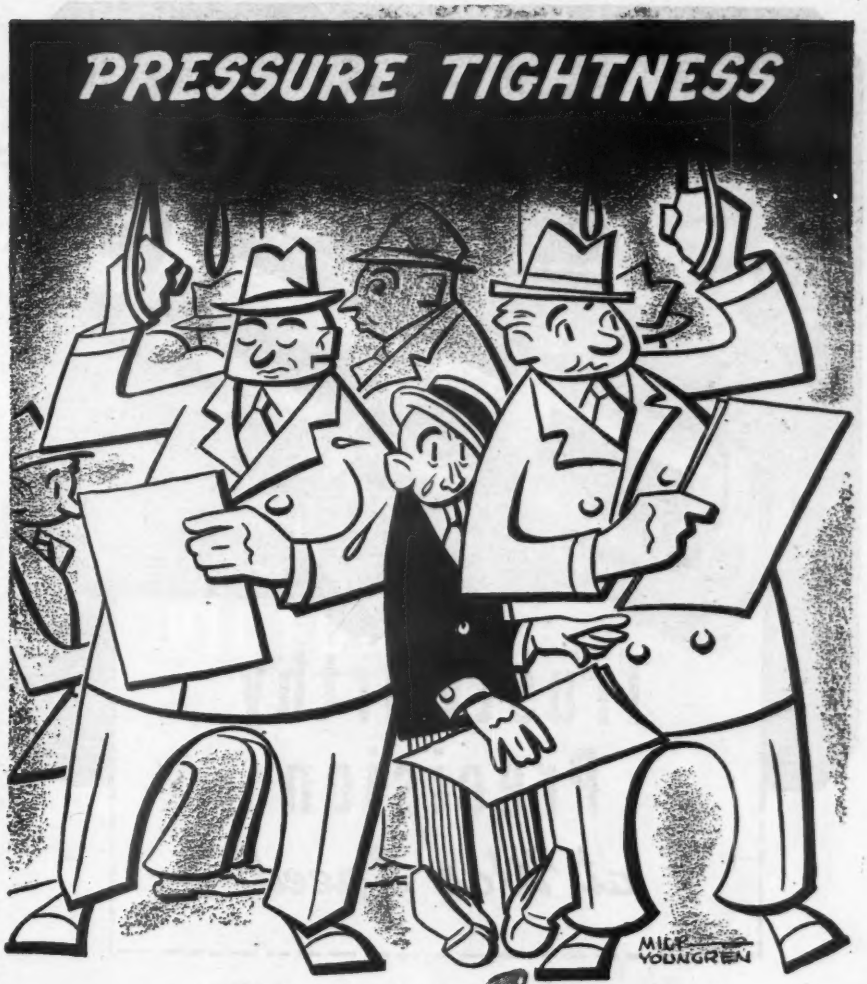
To bring power to the tunnel, a separate transformer station was erected just outside the motor room. In it are transformers which step down the 26,000 v. of the transmission lines to the 6,600 v. needed to operate the tunnel equipment.

Location of the laboratory adjacent to the test section of the tunnel, plus some new Boeing ideas in design of the test section itself, make the tunnel the most convenient ever built. The testing section opens directly into the operations room, with the floors of both at the same level. Operating and instrument panels are located directly outside of the testing station.

An overhead monorail runs the length of the operation room and over the test section of the tunnel, allowing model airplanes to be picked up in the model shop on the first floor and raised through a trap door to the operation room where they are moved into the tunnel throat without dismantling.

Models up to 11-ft. wing span can be accommodated in the test section. Three methods of mounting them are provided, two horizontal and one vertical, to provide for the widest possible variety of testing positions.

For low-speed testing, the section is closed by side doors and a top section. For high-speed work a large pressure



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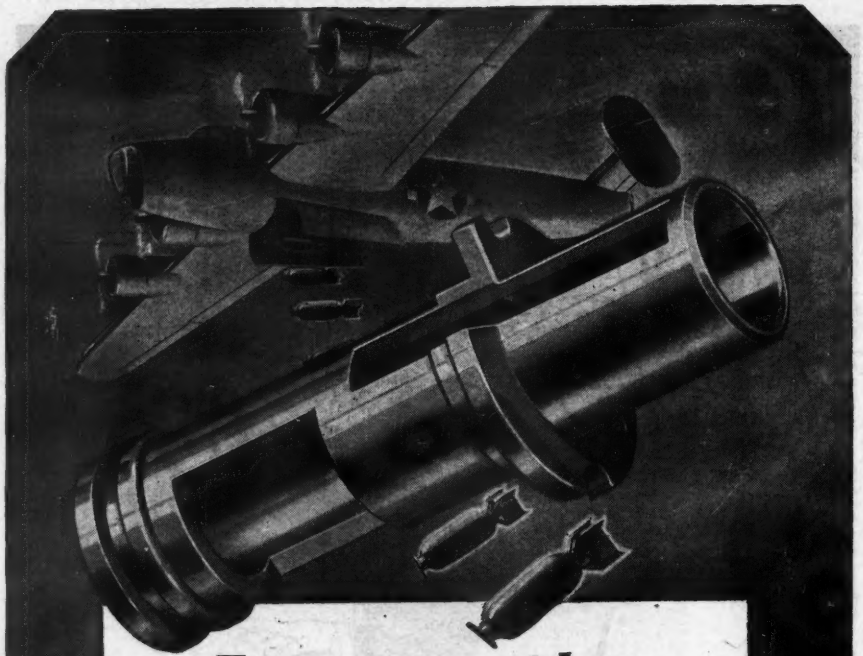

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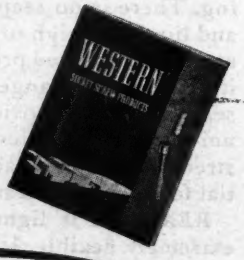

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cap slides over the entire testing section, being moved into place by a powered mechanism, keeping air pressure inside equivalent to that of an altitude of 12,000 to 15,000 ft. Ample windows are provided in both enclosures so that action of the models can be observed freely from either side or the top of the test section.

Heart of the testing section is the intricate balance assembly, designed and built at Boeing, and upon which the model planes are mounted. This balance measures lift, drag, pitch, yaw, roll, and side force. It will measure lift, for example, from $\frac{1}{10}$ lb. to 8,000 lb. In the balance pit all forces and moments exerted on a model are transferred into electrical impulses which are carried to the instrument panel in the operation room and there registered on dials.

At any given time, when the operator wishes to make a permanent record of dial readings, he can throw the switch of an automatic printing machine which instantly records the readings on paper tape. These recordings are time-savers because they eliminate much tedious computation.

Actual operation of the tunnel is concentrated also in this panel board, including the starting of motors, fan speed, amount of power delivered to motors in a model, closing of the pressure cap, and control of lights.

Another convenient feature is a quick entrance door to the testing section which allows an operator to enter the section to change position of the model, remove propellers, or make some adjustment without the necessity of opening the large side doors. Controls on all doors leading into the actual tunnel will automatically turn off the fan if a door is opened.

Primarily, the Boeing wind tunnel is unusual in the way in which proven devices, features of design, and equipment were selected and built into it. It is named in honor of Edmund Turney Allen, who helped chart the course of the future for Boeing and for all aviation.

Future of Technology

(*Continued from page* 120)

54 times the prewar volume of traffic.

This increase should be achieved with airplanes which are conventional in design and arrangement, taking advantage only of normal aerodynamic and structural refinements. This is the basis of the design of the C airplane.

Recently, jet propulsion and the use of turbo-compressor engines has received wide consideration. But it is not believed that propellerless transport airplanes will be commercially practical for a long time to come. However, possible use of a compressor and turbo combination with a propeller does offer distinct possibilities for use in transport operations. In Part III of this series we will survey the possible advantages of airplanes equipped with turbo-compressor engines and propellers in further reducing airline operation cost.

Takeoff Analysis

(*Continued from page* 153)

the great majority of pilots leave the water at trim angles between 7 and 9 deg.

If the analyst finds difficulty in checking computed takeoff times during actual flight tests, this factor should be investigated first—for its effect on takeoff time, and even more so on takeoff distance, is appreciable. For computations intended to predict normal service operation the lift coefficient for a trim, τ, of 8 deg. should be used to determine V_s. This will result in greater accuracy under these conditions.

The examples presented, however, are all based on the formal procedure for determining maximum performance and use a getaway lift coefficient equal to 90 percent of the $C_{L_{max}}$.

3. For convenience C_V is transferred to V and V^2 in mph. and tabulated in columns 2 and 3.

4. Static $C\Delta$ at rest is computed,

$$C\Delta_0 = \frac{\text{Total G. W.}}{w \times b^3} \qquad (22)$$

which gives the approximate $C\Delta$ with which to enter the trim curves. Due to the very low speed and slight unloading of the hull by the wing, the hull load coefficient, $C\Delta$, at a $C_V = 1.0$ will be very slightly less than this static value.

5. Next step is to determine the hull trim which then fixes the aerodynamic lift and drag and the water resistance. The vertical accelerations of the airplane are second order terms and can be assumed equal to zero. As a consequence of this assumption, the airplane can be considered in a state of vertical equilibrium or,

$$\Delta + L - W = 0 \qquad (23)$$

where Δ is the load supported by the hull, L is the load supported by the wing, and W is the total gross weight, all in pounds.

Trim of the hull must then be of such magnitude so as to give a value of $C\Delta$ and C_L which will satisfy the equilibrium equation. Correct trim is obtained by trial and error. Upon assuming a trim, determine the aerodynamic lift coefficient, C_L, with ground effect. Compute the value of aerodynamic lift, L in pounds,

$$L = .00256 C_L S V^2 \qquad (24)$$

where S is the wing area in square feet and velocity is in mph., and subtract the lift from the total gross weight which leaves the load on the water, Δ. From this value compute the load coefficient from load coefficient equation (12) then using this value of $C\Delta$ and C_V, re-enter the trim curve and check the value of trim against the assumed value. If the trim comes out higher than the assumed value, it indicates the original assumption was low, because the lift was too low as a result of the low trim. This, in turn, made it necessary to have more hydrodynamic load, Δ, than could be obtained at the assumed trim and speed, consequently the higher value of computed trim.

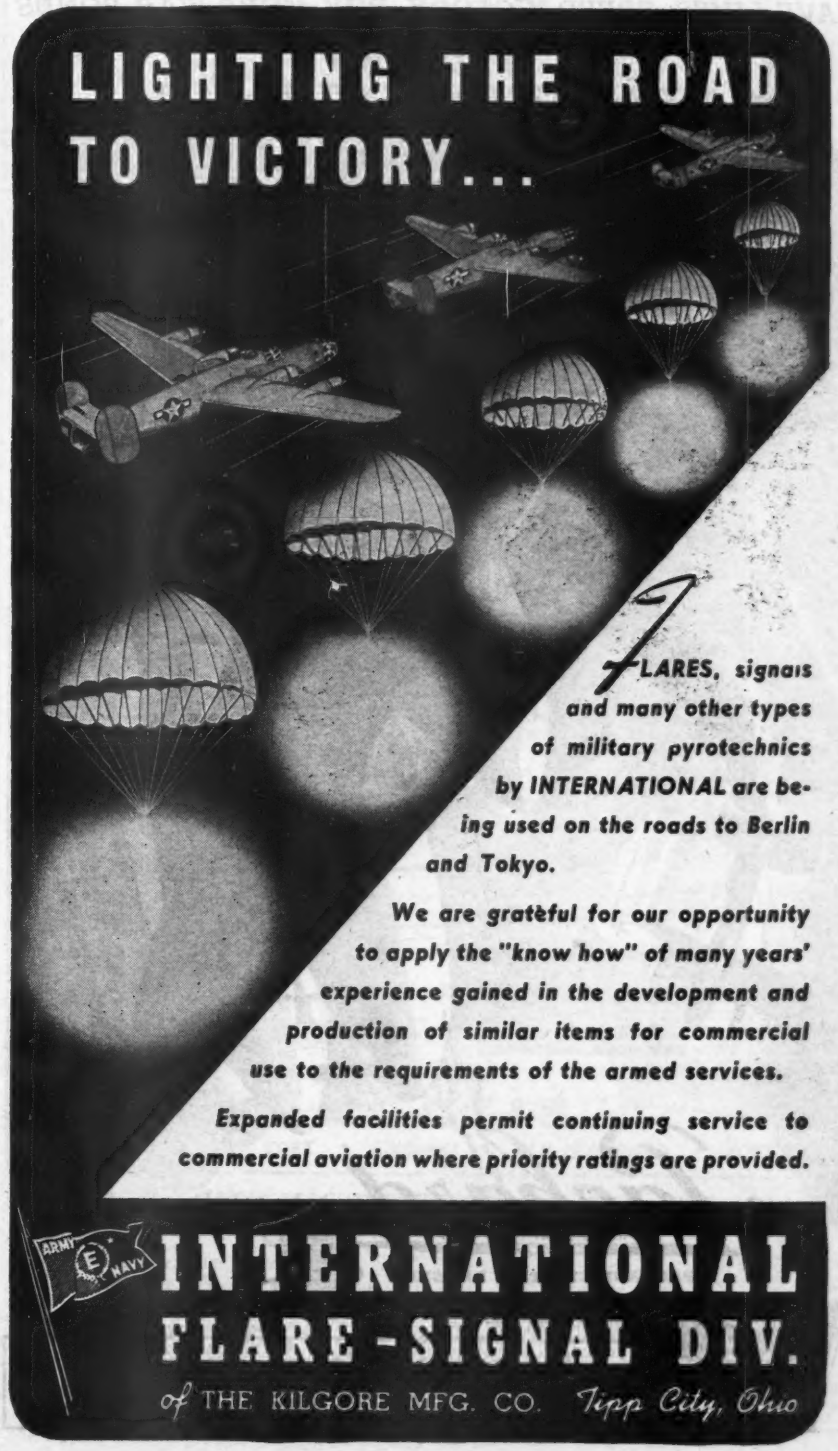
By the same token, if the trim comes out lower than the assumed trim, it indicates the assumed trim was too high, necessitating another assumed value somewhat lower. The correct trim can usually be obtained in two or three trials. During the first stage, particularly where the hull free trims and the trim changes little with loading, the first assumptions are usually valid.

6. Proceeding in this manner, the table may be filled in through the column of $C\Delta$ never proceeding to a new new C_V until the trim for the previous C_V has been checked. It is usually best practice to fill in the entire integration only through the $C\Delta$ column before proceeding with the columns of C_R, R, C_D, etc. If new assumptions are necessary this prevents a considerable amount of recalculation.

Wooden Prop Life

(*Continued from page* 177)

use, to clamp tip metal to blade. Then cut metal ⅛ larger than blade tip and bevel to knife edge (Fig. 12). Turn this edge over blade with a hammer and solder in place using 50/50 solder, filling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screw heads at the same time. File off excess solder and polish with fine emery cloth. Drill three No. 44 holes in tip for drainage, using old tip as a gage for position.

Cut new airplane cloth to size required to cover both outer faces of blade. Apply rather thick solution of glue. Starting at leading edge, lay fabric, on flat side first, then round trailing edge and over cambered side. Joint is made at leading edge where it will be covered by tipping. Smooth out as applied so as to remove bubbles beneath fabric. Trim off excess fabric. Allow glue to dry for 6 hr., then apply two coats of nitrate dope, dry ½ hr., and sand lightly. Apply pigmented dope and varnish with rest of propeller.

Clean all finger marks with sandpaper or scraper, apply one coat of full body varnish, and let dry 16 hr. Sand lightly with No. 5/0 sandpaper and attach decalcomania if required. Apply two more coats of varnish, allowing 16 hr. between coats. Obtain final balance by applying varnish to flat side of light blade. Coat hub and bolt holes with varnish. Finally, store in horizontal position, resting on hub only.

Even though a propeller may be almost perfectly balanced on the stand, there may still be considerable vibratiion when running. For this reason, dynamic balancing (balancing while in motion) is becoming more and more common as a means of eliminating vibration.

The method here detailed is a modification of that used by Braniff Airways (described on page 214 Apr. 1943 *Aviation* by B. J. Cumnock, senior maintenance engineer of that airline). The vibrometer is made from a piece of card shaped and ruled as shown in our Fig. 13. This card is fastened to steering column. Vibrations from engine or propeller cause the card to vibrate sidewise, causing the triangular center to give an optical illusion of a central inverted "V" which varies in height with the extent of the vibration.

By recording the amount of vibration as measured before the experiment, a basic height for the central inverted "V" can be found. As small balancing weights are added experimentally, first to one blade and then the other, a point will be found where the motion of the vibrometer will be less than with any other weight.

This will enable the operator to find not only which blade required addition of weight, but also approximately how much weight will be required. Ordinary friction tape, applied with the edges trailing, is good material for this experiment. A very close approximation to perfect balance may be obtained by this method.

Helicopter Piloting

(*Continued from page* 117)

ways to introduce a safety device against such an uncomfortable eventuality—and you can count on this matter being taken care of. One way is by means of an "automatic pitch-control" device, so that as the blades cone higher their pitch will

be automatically decreased, until it is low enough for them to start auto-rotating. As soon as that happens, they speed up again and centrifugal force is restored in full. With such an arrangement, it would be impossible for the rotor ever to fold up.

However, in the XR-4, we had our share of mechanical difficulties from other sources, and we decided not to complicate the problem by trying any gadgets that were not absolutely necessary. We knew that, with proper training, it was safe to fly the craft without an automatic pitch device, simply warning all pilots not to let the rotor slow down below a certain safe turning speed. They were warned, also, that in case of engine failure, the very first mandate was to decrease pitch instantly to the auto-rotative stage.

However, as I have already mentioned, the synchronization between pitch and throttle in the XR-4 was not perfect, and the pilot had to readjust throttle for each change in pitch. Since an error could be extremely serious, intensive and careful practice is the next phase of any student's training.

Several hundred feet in the air, Kilpatrick went through the process of slowly moving the pitch-lever up and down, up and down, being certain to keep the rotor speed always above the safe minimum. It was hard work and plenty of it —but the idea gradually became firmly indoctrinated. Then it was only a matter of a little practice to take over the whole job of handling all the controls in the air —stick and rudder, pitch and throttle.

With the fundamentals well in hand, we advanced to the hovering stage. The job was simplified by the airwork we had already covered, but it gave me a certain self-satisfaction to find that Kilpatrick shared my early difficulty of trying to hold the craft accurately over one spot. It is a strangely slippery feeling, this hovering business. When you first start, it's like trying to balance on top of a beach-ball in the water. Of course, you have controls that the beach-ball lacks, so after you have gained experience it becomes really quite simple.

When Kilpatrick's skill had developed to the point where he could keep a blade of grass just about where he wanted it, and could land smoothly without drifting over the ground, I felt he would gain confidence if I were to send him up for a little solo practice in hovering. I myself lacked experience as a helicopter instructor, and my haste to "turn him loose" was nearly disastrous, because one of the most troublesome things in handling the XR-4 was coming to a stop from forward flight. It required a great deal of coordination of all controls to do it properly, and I had not given Kilpatrick any instruction in this phase. It never occurred to me, when I stepped out of the ship and told him to "just take it up and hover a minute or two," that he might inadvertently start flying forward and not know how to stop the craft.

All went well for his first flight. He took a few seconds to get accustomed to the ship without my weight in it, then he steadied down for some good hovering.

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After the landing, I signalled that it looked okay and he might try it again.

This time he began to creep slightly forward. He pulled back on the stick to stop it, but the ship climbed up a foot or two. This rather startled him and, being a fixed-wing airplane pilot, he thought the best way to keep from climbing was to put the nose down and dive. So he did with the result that he picked up more speed, and consequently more climb.

By now, I had begun to worry. I started dog-trotting after the ship in the 90-deg. shadeless heat of Wright Field, mumbling to myself the instructions that I wished he could hear: "Drop your pitch, Doug! . . . No, not so much . . . Keep up your rotor speed! . . . Stop trying to land with throttle . . . Back on the stick, now . . . That's fine—now up on the pitch . . . No, don't *over*control!" And so on all across the field.

Occasionally he would seem to be pretty well set, then something would happen and off we'd go again. After what seemed hours (it probably was not more than two or three minutes) he steadied down into good hovering and finally got the machine back onto the ground.

As I panted up to the ship, he was shaking his head and wiping the perspiration from his face.

"What did I do wrong?" he grinned sheepishly.

"You did all right," I said. "You got it down whole, and you taught me one thing: I'll never send another student up solo until he has learned to make transitions from forward flight into hovering."

In the next lesson, transitions were the order of the day. My own training in this phase had been gradually built up by the extensive starts and stops that comprised so much of our early testing. I didn't realize how troublesome it might be to someone who had not gone through that experience.

Transitions require coordination of all controls, if they are to be done smoothly. As the pilot approaches the point of intended landing, he pulls back slightly on the control stick and expects to stop. But the craft still has a certain amount of forward speed, so he finds himself zooming upward. To correct for this, he lowers the main pitch-lever, simultaneously turning the throttle grip in order to keep the engine at proper speed. This changes the torque of the main rotor, and the ship begins to turn until a correction is made in the rudder-pedal position.

Then, as the craft slows down and begins to settle, all those readjustments must be repeated in reverse order, viz., increase pitch, adjust throttle, change rudder pedals back to their original setting, and push the control-stick forward.

It is possible, of course, to follow those steps one at a time, as Kilpatrick did on his first solo, but this is a very jerky, unsteady procedure. To do it smoothly, they must be coordinated *before* their need becomes apparent in the antics of the machine. But I was still learning how to teach, and it took a great deal of main strength and awkwardness—coupled with superb stick-to-it-iveness on Kilpatrick's part, to arrive, finally, at a sort of mutual understanding between the student and the ship.

From that point onward, it was smooth sailing. I am deeply grieved that a bomber crash put a tragic end to Kilpatrick's career so that he cannot enjoy with us now the fruits of his willing labor in this field.

On this matter of coordination, I was recently about to give an advanced check flight to one of my students who had about 15 solo hours in the ship. I asked him whether he had found anything that particularly troubled him.

"Yes," he replied. "When I am coming in to land and am just pulling to a stop in the air, the ship seems to take control and does all kinds of things that I don't assume any responsibility for! She rocks around and twists from side to side. There doesn't seem to be much I can do about it."

A brief flight convinced me that he was not applying rudder at the same time that he increased pitch. This caused the ship to turn and rock sidewise, and it took several seconds to straighten it out. As soon as the error was clarified for him,

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and he began to use rudder simultaneously, without waiting for the need to become apparent, the trouble disappeared.

One of the most difficult things for students to overcome is an instinctive, overpowering desire to always move forward. Pilots of conventional airplanes are taught to "keep flying speed;" they dare not slow down, especially when at low altitude. This is true to a certain extent even with autogiro pilots, who have learned that, below a certain speed, the autogiro must settle. Therefore a good deal of time is spent in forcing the helicopter student to hover over one spot. When a student became particularly difficult on this point, I would often make him fly backward for long periods of time, on the theory that, once he had acquired this facility, he would then be quite satisfied to hover.

My first British student, Wing Comdr. R. A. C. Brie, Royal Air Force, was one such case. He found it difficult to unlearn his extensive autogiro experience. Even after he soloed, it was obviously a real effort for him. He would creep slowly forward at walking speed, while I wandered along beside trying to figure out how to stop him. At last I stepped out in front and held up my hand like a traffic cop. He approached, laughing, and pulled to an unsteady stop with the nose of the machine practically in my hand. Then I waved him back, and slowly, by fits and starts, he retreated to a safer position.

Later on, when I decided to leave him to his own devices, he crept closer and closer to the fence and trees bordering the field. I could see him making a stupendous effort to back up, but he was still in open conflict with his autogiro training. Finally he soared upward and over the trees, "doing an inadvertent circuit of the field," as he said later; but fortunately I had learned from Kilpatrick to teach every student transitions before solo, so he came through with a highly creditable approach, hovering, and landing.

It is quite probable that Brie shied away from backward flight because of an experience early in his training. He had the usual pilot's instinct to "get the tail down," when landing; but in the helicopter, if you get the tail down, you don't land. Quite the contrary. You take off—and backward!

Brie did that once. The more he pulled back on the stick, the faster we reversed—and the faster we reversed the more he pulled back on the stick. We flew tail-first half-way across Wright Field, with Brie shouting, "I can't get the blasted thing down!"

It was with Maj. L. B. Cooper (now Lieutenant Colonel) that I had my worst troubles. They stemmed not from Cooper's piloting abilities but from his avoirdupois. Day after day, the XR-4 would gallantly strive to hover with his 230 lb. added to my weight—and day after day, temperatures of 95 deg. with calm air would nullify its efforts. We finally let the wind-indicator decide whether or not Cooper would get any instruction.

It was Cooper who effectively demonstrated the remarkable stability of our

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7. **Drill parts after hardening to avoid warping or distortion.**
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craft. We were flying around the field one day and I signalled for him to take the controls. Then I rested my elbow on the window and dreamily watched the people below, while Cooper practiced making turns. After five or ten minutes he shouted, "Hey!" He was pointing at the rudder pedals. "Who is operating those?" he said. Neither of us had our feet on them, and yet his turns had been as satisfactory as could be desired!

That quality of the Sikorsky helicopter has become a stock-in-trade. Every flight demonstration I give includes turns without rudder. Moving the stick to one side causes the ship to tilt toward that side, and the tilt is accompanied by an automatic turning. When the stick is neutralized, the craft straightened out positively and without "hunting." Quite steep banks (close to 70 deg.) can be made in this manner. Thus the rudder assumes minor importance in flight, being used mostly for precision hovering—and of course for the inevitable and always present torque compensation.

I had an opportunity at Wright Field to check out Capt. V. R. Haugen. He had flown the VS-300 in the early days of the Army's interest, but he had not been closely associated with our more recent developments. He was one of my star pupils, soloing with less than 3 hr. of instruction.

I found that the average pilot requires between 3 and 4 hr. of training before solo. A great deal of this time is spent forgetting the many practices and prejudices that he carries over from flying conventional airplanes—practices such as getting the tail down when landing, and prejudices such as the aversion to slow speed and low altitude. From that point of view, I am led to believe that it may be easier to train non-pilots than to convert those who already know how to fly conventional designs.

It is obvious, of course, that, once a skilled pilot has checked out on the helicopter, all his previous experience and "air sense"—meteorology, avigation, aerodynamics, coordination, and that indefinable "at-home-ness" by which you can recognize a good pilot just as you can a good automobile driver—will be brought to bear. In this way, he will be ahead of a non-pilot who has accumulated the same number of helicopter hours but who lacks the background of air experience.

This leads to a question that is often asked: "If I plan to own and fly a helicopter after the war, will it help to learn on a fixed-way airplane now?" On the basis of the foregoing, the answer may be that the detailed knowledge you acquire in the relatively minor matter of manipulating the controls may be gained as readily in the helicopter as in a conventional airplane. But if you spend 100 hr. or 1,000 hr. flying an airplane now, you will be that much more capable of using a helicopter to its fullest advantage when the time comes.

A warning is in order here, too: The 3 or 4 hr. of instruction before solo do not constitute the beginning and the end. They only bring the pilot to the point where he is safe to fly alone but proficiency and

accuracy have not even been touched. The next 15 to 20 hr. are spent pursuing a planned course that covers the whole list of things a helicopter pilot should be capable of doing. To name them—

Power-off glides (auto-rotation)
Turns over a spot
Landings within 6 in. of a mark
Hovering cross-wind and tail-into-the wind
"Jump" takeoffs
Quick starts and stops
Hovering at higher altitudes
Takeoffs and landings, both cross-wind and tail-into-the-wind
Vertical descent from altitude without power or with part power
Rough-air operation

—And many refinements and ramifications of the above. In any event, until he has mastered these skills, the helicopter pilot will not be capable of even backyard landings, much less the much-discussed roof-top landings that may come sometime in the more distant future.

But for those who may be disheartened by this thought, there is a reasonable hope of some improvement. We have thus far expended no effort in simplifying the helicopter's controls. We arrived at a control arrangement that could be safely operated by two arms, two legs, and a brain; and immediately we had reached that stage the Army wanted it. Simplification is easy and will come when time permits. In the interim, we accept whatever criticism may be forthcoming, believing that, under the urgency of war, we really haven't done too badly.

At Wright Field that summer, two other men received training: Col. "Mike" Lee, who was doing a most excellent job of 'copter flying before he was transferred to another assignment; and Col. E. Gabel (who unfortunately was killed in a West Coast glider accident in 1943, before he had further opportunity to apply his unusual talents to the helicopter).

Gabel arrived from Washington one morning about eleven o'clock, on his way west, and he announced that he wanted to learn to fly the helicopter before he left—at 5 o'clock that night.

"But that's impossible," we said. "For one thing, the ship is being overhauled. But even if that weren't so, it would take you more than a day to learn."

"All right," he replied, "I can arrange to stay through tomorrow. Just give me as much training as you can and I'll finish up later."

Next morning I began, and was astonished at the rapidity with which he learned. Before I realized it, he was ready to solo—with less than 2 hr. instruction. This was so out of line with my other students that I distrusted my own judgment, so I asked Col. Gregory to give him a check ride before I turned him loose. Within a few minutes Gregory stepped out of the ship—and Gabel soloed, his wish accomplished.

This training period saw the XR-4 pass another milestone—perhaps the most important one in its career. Heretofore, helicopters had been regarded as temperamental, delicate, and subject to endless troubles—they were an interesting experiment, but certainly not recognized flying machine. On July 23, 1942, however, the XR-4 passed the 100-hr. mark. During those 100 hr. in the air, she had broken trail for all of the important performance factors in this type of aircraft, she had completed an epochal cross-country flight, and she had permitted five other pilots besides myself to secure basic helicopter training. This record was achieved in only 6 months and 9 days from the time her wheels first left the ground.

The helicopter had established a truly phenomenal record—had finally merited deserved recognition.

Graphic Solutions

(*Continued from page* 191)

$$t = \frac{b'}{n_b - n_a}$$

The reason formulas (5) and (6) are not included with the first four is that under these two special cases, the time to make a latitude check is also the time the track would be checked, since at this time the body is in the abeam position.

The alert person will probably note that formulas (5) and (6) can be used in a mathematical solution to determine the time to make the latitude check, by

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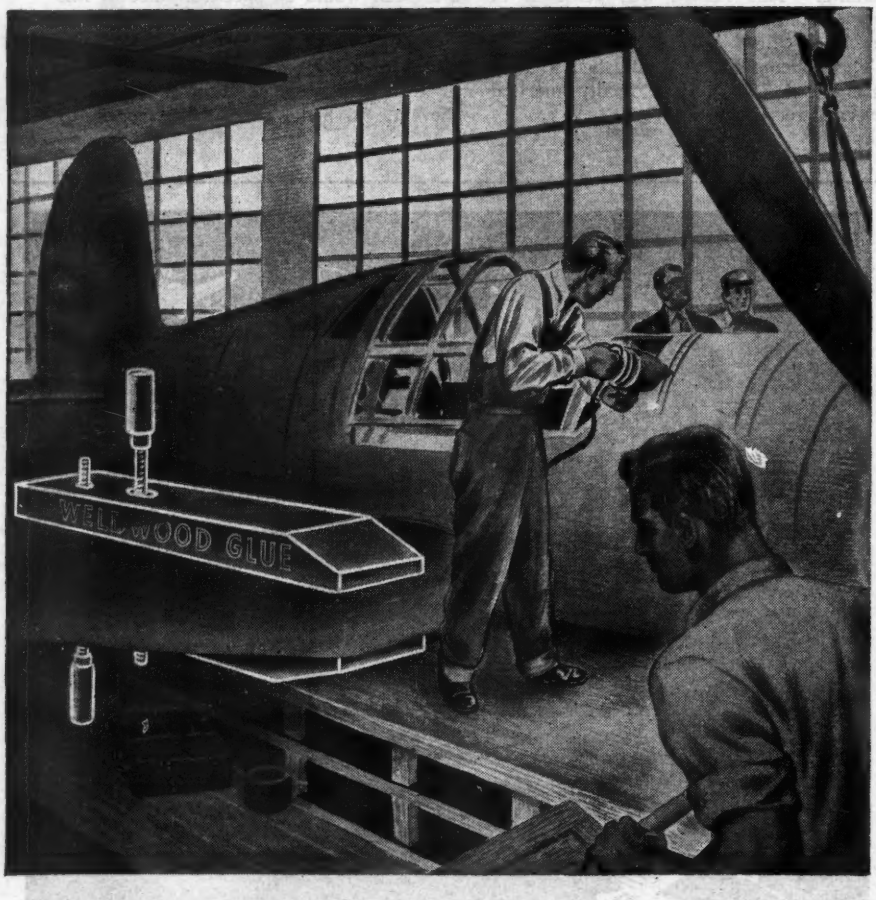

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making the slight revisions incorporated below:

(7) When track is directly east or has eastward component.

$$t' = \frac{b'}{n_b + n_a}$$

(8) When track is directly west or has westward component

$$t' = \frac{b'}{n_b - n_a}$$

where t' is the amount of time in minutes from the time of the D.R. No. 1 position (to be added when positive and subtracted when negative). Result is the time to make the latitude check by formula instead of the previously explained grapical solution.

Summary of the Revised Method

(1) Select a body that makes upper transit with your track near the zenith position (using the *Air Almanac*).

(2) Plot your track on a plotting sheet for the portion of the course at which upper transit will occur.

(3) Plot the declination line of the body. If it falls off the sheet, draw a sub-declination line in such a position that a hub can be obtained.

(4) Determine the time for D.R. No. 1 and D.R. No. 2 and plot your position and the body's position for these two times. Usually, for a small area plotting chart, the interval of time t_a from D.R. No. 1 to D.R. No. 2 will not be more than 10 min.

(5) By graphical construction obtain a hub (it does not need to be a true hub).

(6) A meridian drawn through the hub gives position *m*, which determines the time for checking latitude. Or, by formula (7) or (8), the time for making the latitude check can be determined.

(7) For finding the time to check track, select the proper equation from (1), (2), (3), or (4) and solve for t. Combine t with the time of D.R. No. 1, which gives the final answer. At this time the body will be in the abeam position.

The above merely determines the time at which latitude and track are checked.

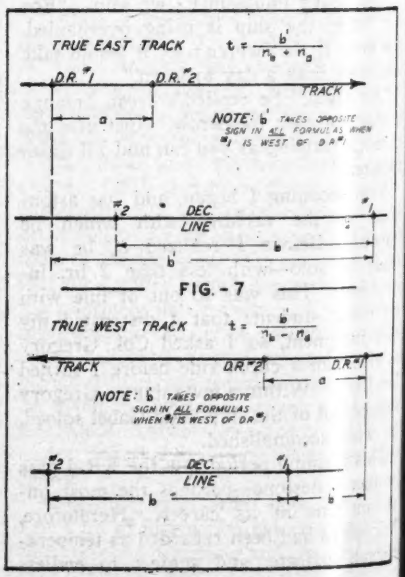
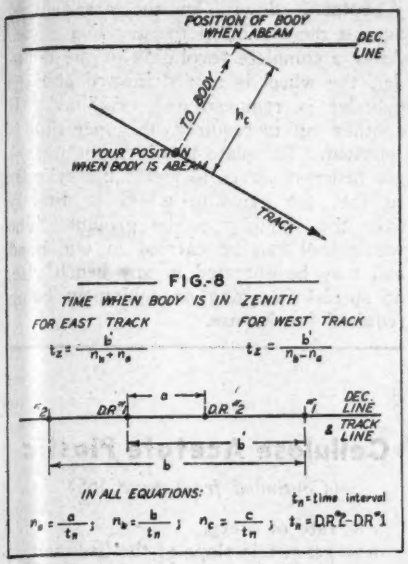


FIG. - 7



To check latitude:
Latitude = Declination ± (90° — H_o)
where H_o is the corrected sextant or octant reading, the *plus* being used when the body is south of you, *minus* when the body is north of you, for the Northern Hemisphere. The use of plus or minus would be opposite for the Southern Hemisphere.

To check track: the abeam position of the body makes the track in reality a Sumner line of position. By using your abeam position as assumed position, as in the Marc Saint Hilaire method for obtaining a fix, difference between H_o and H_c is the distance in nautical miles you are to the left or to the right of the intended track. H_c is found by H. O. 214, by direct calculation, or by: $H_c = 90° - h_c$ where h_c is in nautical miles (as in Fig. 8).

Time When Body Is In Zenith

Occasionally your track may coincide or be along the body's declination line. When such is the case, the time at which the body is in the zenith position can be readily determined by the following:

(9) When track is on the declination line and your direction is east

$$t_z = \frac{b'}{n_b + n_a}$$

(10) When track is on the declination line and your direction is west

$$t_z = \frac{b'}{n_b - n_a}$$

where t_z is the amount of time in minutes to be combined with D.R. No. 1 time. All other terms in the formula are as in the rest of the article.

Hoosier Airport

(*Continued from page* 172)

then staked in place with a small blunt-ended punch—and the cylinder is ready for use, so far as concerns the sparkplug bushings.

Trouble had been experienced from the shoulder worn at the top of the cylinder by the top piston ring. Regrinding usu-

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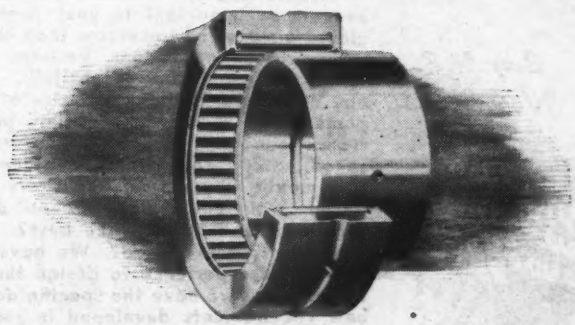

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ally calls for a rather complicated machine with considerable time for setting up. To obviate this lost time and enable the work to be done quickly by comparatively inexperienced men, the grinder sketched herewith (Fig. 6) was constructed.

Two old pistons were fastened together to form a guide for the cylinder which required the shoulder removed. Running eccentrically through these pistons was a 2-in. hole into which was smoothly fitted a steel pipe which could be turned by a lever (at left in sketch). Mounted eccentrically inside this pipe is a shaft, driven by a ¼-hp. electric motor and carrying a small, smooth grinding wheel.

In use, the pipe is rotated so that the grinding wheel is lower than the edge of the pistons. The cylinder to be ground is then slipped onto the pistons until it bears tightly against the plate in the center of the picture. The motor is then started, and the 2-in. tube carrying the motor and wheel are turned by the hand lever until the wheel cuts the shoulder in the cylinder bore very lightly.

Keeping the lever in this position with one hand (though it will stay there due to the friction in the tube) the cylinder is rotated slowly by the other hand against the motion of the grinding wheel. After a complete revolution of the cylinder, the wheel is moved inward and the cylinder is removed and examined. If another cut is required, the operation is repeated. The plate to which the pistons are fastened serves to locate the cylinder so that the grinding wheel is directly over the shoulder to be ground. The whole tool can be carried in one hand and may be operated in any bench vise, no special fastening or equipment being required for its use.

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Cellulose Acetate Plastic

(*Continued from page* 165)

r = rate of creep,
n = geometric slope of the line, and
m = value of the stress corresponding to a rate of creep of one.

This equation for the first group of tests is $\sigma = 1{,}440\ r^{0.085}$.

Examination of Fig. 19 shows that aging changes the constant m in above equation but does not change the exponent.

In Fig. 20, stress is plotted against creep occurring in a certain time interval. Curves for time intervals of 200, 2,000, and 6,000 hr. are shown. It may be seen that there is a critical value of stress at about 1,500 psi. below which creep is relatively small and above which it is relatively large.

If it be assumed for purposes of illustration that a creep of 1 percent in a time of 6,000 hr. (about eight months) is the limiting value above which structural damage may be said to occur for plastics, then a creep limit may be defined. It would be: The maximum stress that can be continuously applied at a constant temperature and relative humidity for a period of 6,000 hr. without causing creep of more than 1 percent. Under this definition creep limit for cellulose acetate as obtained from the first group of tests is 1,000 psi. at 77 F. and 50 percent relative humidity.

Effect of duration of loading on stress which would cause fracture as a result of creep is shown in Fig. 21, where stress is plotted against time required to cause fracture at the particular stress. Double logarithmic plotting is used. Open circles represent data for long-time fracture tests started in Nov. 1940. These were similar to creep tests, except that stress and time for fracture were the only data obtained.

The filled circles represent data taken from the creep tests shown in Fig. 18. The latter tests were started in Aug. 1941. An examination of Fig. 21 shows that time for fracture is much less for the 1941 tests than for the 1940 tests.

Thus aging has reduced time for fracture at a given stress—but aging, as shown above, also decreased rate of creep. It should, however, be mentioned that the duration of aging was about three times as long for the two sets of fracture tests as for the first two sets of

In Tribute to Colin Kelly

BY JAMES M. SESSIONS

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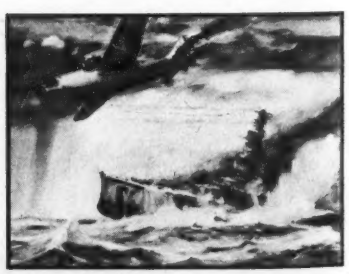

Artist Sessions painted the picture (see reverse side) of the sinking of a Jap battleship by Captain Colin Kelly shortly after the incident occurred, and before authentic details were available. Plane shown is a Douglas B-18; should be a Boeing Flying Fortress B-17C.

creep tests. Also the aging did not occur over the same period of time for the two groups of tests.

Effect of duration of loading on ductility of the material, as measured by percentage elongation at fracture, may be seen in Fig. 18. Percentage elongation at fracture decreases rapidly at first, then more slowly as time for fracture increases. For a 200-hr. test, the percentage elongation at fracture was 48 percent. For a 6,600-hr. test, the percentage elongation at fracture was 48 percent. For a 6,600-hr. test, the percentage elongation at fracture was 39.5 percent.

Fig. 22 shows the unusual character (as far as metals are concerned) of the fracture for several fractured specimens. During progress of the tension test a considerable elongation and reduction in cross-section of the specimen took place. Character of the tension failure was unlike that occurring in any single metal, in that both brittle and ductile properties are evidenced. The large elongation is evidence of ductility, yet there was no marked localized reduction of area (necking down); the reduction was uniform throughout the test section. The fracture was a transverse plane which is characteristic of the tension fracture of brittle materials (Fig. 22b).

The fracture starts (perhaps at several places at once) as a tear originating at some slight surface imperfection. It spreads, leaving a shiny surface, until rupture takes place. Surface of the rupture shows a fibrous character.

In fatigue tests fracture is propagated in a different fashion. In the case of the circular specimens the plane of fracture was at 45 deg. to the plane of maximum normal stress, indicating shear failure as shown in Fig. 22a. Fracture of the rectangular specimens started in the same way, but due perhaps to shape of the specimen this was a slowly propagating tear having a glass-like fracture, and it was on a plane normal to the direction of tensile stress.

The torsion speciment shown in Fig. 22c twisted around 1¾ revolutions before fracture started. This indicates large shearing deformation, but the fracture was on a 45-deg. helix (a plane of maximum tension stress). Thus again, ductility is indicated by the large detrusion, whereas the fracture is the characteristic of brittle material.

The following conclusions were drawn from a series of tests of cellulose acetate plastic conducted in a closed room maintained at a constant temperature of 77 deg. F. and constant relative humidity of 50 percent.

1. The load resisting characteristics of cellulose acetate are quite similar to those of metals. The differences are largely in magnitude. Also certain factors which are unimportant in the testing or application of metals cannot be overlooked in plastics. For example, small changes in temperature, relative humidity, and rate of strain produce marked changes in measured values of load resisting characteristics of cellulose acetate.

2. Yield point and fracture stress were found to increase with increasing rate of strain for tests in tension, compression, and torsion.

3. Modulus of elasticity in tension and torsion was found to be independent of rate of strain for values tested, but modulus in compression was found to increase with increasing rate of strain for loading in compression. The following values of modulus were found: Tension, $E = 244{,}000$ psi.; torsion, $G = 78{,}000$ psi.; compression, E varied from 204,000 to 278,000 psi.

4. At a tensile rate of strain of 0.04 per minute, the values of upper yield point were: Tension 4,400 psi.; torsion, 3,300 psi.; compression (long specimen), 4,300 psi. And the fracture stress was: Tension 5,500 psi.; and torsion (modulus of rupture) 4,900 psi.

5. Aging of material at constant temperature and relative humidity was found to increase tensile strength about 4 to 12 percent and modulus of elasticity in tension about 15 percent during about one year.

6. A transverse hole in a static tension specimen reduced ultimate elongation in 2 in. to about 8 percent of elongation in a solid specimen. Ultimate strength (based on net area) was found to be about 10 percent less for a specimen with a hole than for solid specimen.

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7. One and one-half months was the time required for compressive yield point and weight to approach equilibrium in an atmosphere of constant temperature and relative humidity.

8. Fatigue tests showed that endurance limit, obtained by computing stress from the flexure formula, varied with shape of specimen.

9. A 45 deg. V-notch reduced endurance limit 53 percent.

10. Aging was found to increase endurance limit about 25 percent in 15 months.

11. Endurance limit decreased by rise in temperature of specimen from internal friction.

12. Speed of testing was found to affect endurance limit. Endurance limit decreased with increasing testing frequency up to 750 cycles per minute. From there on to 2,900 cycles per minute endurance limit was constant.

13. Change in range of stress caused decrease in endurance limit (in terms of alternating component of stress cycle) as mean stress of cycle becomes larger, for values of mean stress in tension.

14. Two regions of constant creep were observed with an initial and an intermediate transition region of decreasing rate of creep. No final stage of rapidly increasing rate occurred, such as the "third stage" in metals.

15. Relationship between stress and rate of creep in the "first stage" was expressed by the form $\sigma = 1{,}440,r^{0.005}$.

16. A critical stress value was observed above which relatively large creep occurred and below which relatively small creep occurred.

17. Creep limit of material was found to be 1,000 psi. (for 1 percent creep in 6,000 hr.) at 77 F. and 50 percent relative humidity.

18. Ductility, as measured by percentage elongation at fracture, decreased with increasing time for fracture (or decreasing stress values).

19. Aging (a change in mechanical properties with time) was observed. For the acetate tested, aging caused a marked decrease in first-stage rate of creep.

Acknowledgments

Tests reported in this paper were a part of the work of the Engineering Experiment Station, University of Illinois, Dean M. L. Enger, director, in the Department of Theoretical & Applied Mechanics, of which F. B. Seely is head. It is a pleasure to acknowledge the help and constructive criticisms of F. B. Seely and H. F. Moore. Certain of the tests reported were performed as part of senior thesis work by K. Young, B. J. Farrell, and J. W. Lessner under the direction of the author. Acknowledgment is made to the Plastics Division of Monsanto Chemical Co. for the material supplied.

Aircraft Heater

(*Continued from page* 160)

is whirled around itself many times. There is no blowing off of the flame. Accumulation of carbon, lead salts, or any other combustion products, on heating surfaces is scrubbed out by the high velocity of the flame. Since fuel and air are mixed within the heater, its operation is independent of additional devices.

Flexibility of this type of combustion maintains high altitude operation. The ideal ratio of air to fuel for proper combustion is approximately 15 to 1 by weight but actual proportions may vary from 65 to 800 percent of theoretical requirements and still maintain combustion, although these extremes do not actually occur in operation because combustion air is regulated by differential controls.

The purpose of this range in fuel-air ratio is recognized when it is recalled that air density at 45,000 ft. is approximately 1/5 that at sea level. These aircraft heaters have been flight tested at 37,500 ft. and laboratory tested at over 50,000 ft.

Table II—Performance of Spray Models

(With Standard Air at 29.92 In. Hg. and 59 Deg. F. 87–100 Octane Aviation Gasoline)

	40,0000 Btu. heater		50,0000 Btu. heater		100,000 Btu. heater		125,000 Btu. heater	
Btu. output per hr.	40,000		50,000		100,000		125,000	
Gasoline lb. per hr.	2.8		3.6		7.0		8.7	
Gasoline pressure psi. (at regulator inlet)	5.0–25.0		5.0–25.0		5.0–25.0		5.0–25.0	
Combustion air. lb. per hr.	57.5		71.5		138.0		171.5	
	Min. Combustion Air Pressure Diff. In. H_2O Required Across Heater							
Combustion air regulation Types	Control Inlet*	Heater Inlet	Control Inlet*	Heater Inlet	Control Inlet*	Heater Inlet	Control Inlet*	Heater Inlet
No combustion air regulation**	...	3.0	...	3.0	...	5.5	...	5.0
Relief dump valve	4.0	...	4.0	...	Not applicable		Not applicable	
Differential regulator	4.0	3.0	4.0	3.0	7.5	5.5	5.0	4.0
Aneroid, used with diff. reg.	***	3.0	***	3.0	***	5.5	***	4.0
Ventilating air (59°F.—29.92 in. hg.)	Lb./Hr.	Pressure Drop In. H_2O	Lb./Hr.	Pressure Drop In. H_2O	Lb./Hr.	Pressure Drop In. H_2O	Lb./Hr.	Pressure Drop In. H_2O
Temperature rise 200°F.	875	1.1	1000	1.5	2160	7.1	2645	6.8
Temperature rise 250°F.	690	0.8	745	0.9	1670	4.8	2110	4.9
Temperature rise 300°F.	570	0.6	590	0.7	1350	3.4	1750	3.9

Current consumption spark transformer—¼ amp.—24v.
Magnetic fuel valve—approximately 1.0 amp. while operating.

*No allowance for drop between control outlet and heater or beyond heater exhaust connection.
**Heated ventilating air pressure must be engineered to maintain minimum combustion air pressure.
***Inlet pressure determined on specific application.

The military significance is considerable: Physical limitations of the plane's crew are greatly extended beyond the 4 or 5 hr. practical limit of endurance without heat; gun breeches and turrets can be kept warmed; bombsights and instrument mechanisms are prevented from freezing; and de-icing and de-frosting is assured.

By designing for a specific job, the company engineers provided an all-purpose heater. Thus, plane engine designs may adopt the short stack on aircooled motors. Tests show that by use of a very short exhaust connection, turned away from the direction of flight, there is a definite reaction propulsive effect which gives ¼ mph. per cylinder benefit. On some of the larger planes, this means 14 mph.

Excess heat in a climb, too little heat at cruising, and none while gliding to a target are some of the other disadvantages overcome. On large planes, which have engines located out on the wings, the weight of duct work to carry the heat to the cabin is saved as well as the extra weight of heat exchangers.

The heater is made in four sizes ranging in capacities from 15,000 to 125,000 btu. hr. and in weight from 7.1 to 43.8 lb. including controls. Larger sizes are being designed for special applications. The Douglas C-54 uses two ram-operated 100,000 btu. units and one 40,000 btu. heater equipped with a blower for general operation. The Curtiss C-46 has three heaters under the floor in front of the wings consisting of two 100,000 and one 40,000 btu. units. The 15,000 btu. unit is usually used in the smaller fighter-type planes for cockpit warming and windshield anti-icing. Batteries of heaters are being engineered into several large planes for wing and empennage anti-icing.

The 15,000 btu. unit is of vaporizing type with no regulation except heater combustion air orifice or with dump relief valve. The 40,000 to 50,000 btu. capacity unit is made in both vaporizing and spray types, with or without differential air regulator or with dump relief valves. All spray types have sparkplug standard ignition and the vaporizing-type uses glow-plugs.

The larger 100,000 and 125,000 btu. models are spray-types with or without differential air regulator. (Aneroids are added to the regulators for extreme altitudes.) The 100,000 btu. size may be had in the vaporizing type for special applications.

Hot-Doping

(*Continued from page* 178)

amount of time consumed in this work may be fully realized when it is considered that each flying boat has 3,120 sq.ft. of fabric surface.

Not included in this estimate were delays, sometimes 50 to 70 hr. per job, when humid weather prevented doping because of blushing of surfaces as a result of moisture condensed within the dope during drying periods. Furthermore, during adverse weather, mildew quickly at-

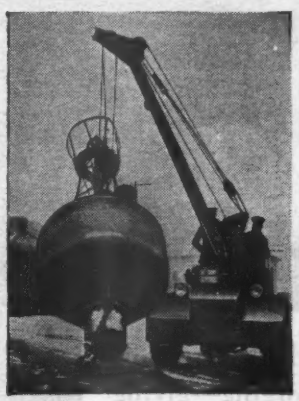
ROUSTABOUT CRANE

The Free-Roving Tractor Footed

- Loader
- Unloader
- Mover
- Carrier
- Stacker

• MC-4 Roustabout Crane—long handling range, fast travel with load, easy steering. Ball-bearing, running-in-oil construction.

Rear view MC-4 Roustabout Crane



MC-4 totes easily an ocean-going buoy

For Fast, Efficient Low-Cost Load Handling You Need the MC-4

IT KEEPS THINGS to 7½ tons moving around your plant, airport, railroad, dock. . . . It's where you need it when you want it, tireless, easy to run, low in operating cost. . . . It pays for itself quickly in saved time, manpower and expense. . . . Modernly engineered and built for years of overwork. . . . Hundreds of users say they wouldn't be without their Roustabout Cranes, keep them in daily profitable use. . . . It pays you to write for the whole story—today, now.

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637 NEWMAN STREET • MANSFIELD, OHIO

ROUSTABOUT CRANE
Roustabout Cranes
By Hughes-Keenan
Load-Handling Specialists Since 1904

tacked unfinished fabric and greatly decreased its strength. It was obvious that a new method of doping had to be found so that schedules could be maintained.

The new technique now employed on all PAA flying boats involves heating the viscous colloidal dope to 175 deg. F, at which temperature its viscosity is lowered sufficiently to permit spraying with a standard spray gun. More solid material per coating operation is applied by heating the dope than by reducing its viscosity through the use of thinners. Four or five coats applied to the fabric give the same protection as the eleven formerly required, and a high degree of tautness is insured.

The spraying process also has proved to be a great time saver, with only 50 hr. per sq.ft. consumed from start to finish. Complete protection against mildew and dry rot is afforded new surfaces by the addition of a fungicide to the primary coat. Moreover, it is no longer necessary to lose valuable time waiting for dry weather, because the danger of blushing is entirely eliminated by the use of hot dope. There is also an average weight saving of 84 lb. per aircraft.

Although the hot-dope technique seemed to eliminate all difficulties from the practical standpoint, a major problem arose which threatened to make the entire program unworkable—that is, could a hose be found that would withstand conveying organic chemicals at elevated temperatures and at the same time resist the rough handling it would receive in a busy hangar?

In the search for a solvent-proof, wear-resistant conduit, many types of hose were tested and ruled out. Some deteriorated as a result of heat or chemical action, particularly while spraying the first coat containing fungicide. Other hose contaminated the dope, so altering its quality as to weaken the surfaces sprayed. One particular hose dissolved completely, and the residue, mixed with the dope, was deposited on the surfaces sprayed. Results were a lingering nauseating odor and a completely unsatisfactory finish. Still other types broke when dragged across the floor, when pulled up to high control surfaces, or even when stepped on. And some types proved to be unequal to the task on all three counts.

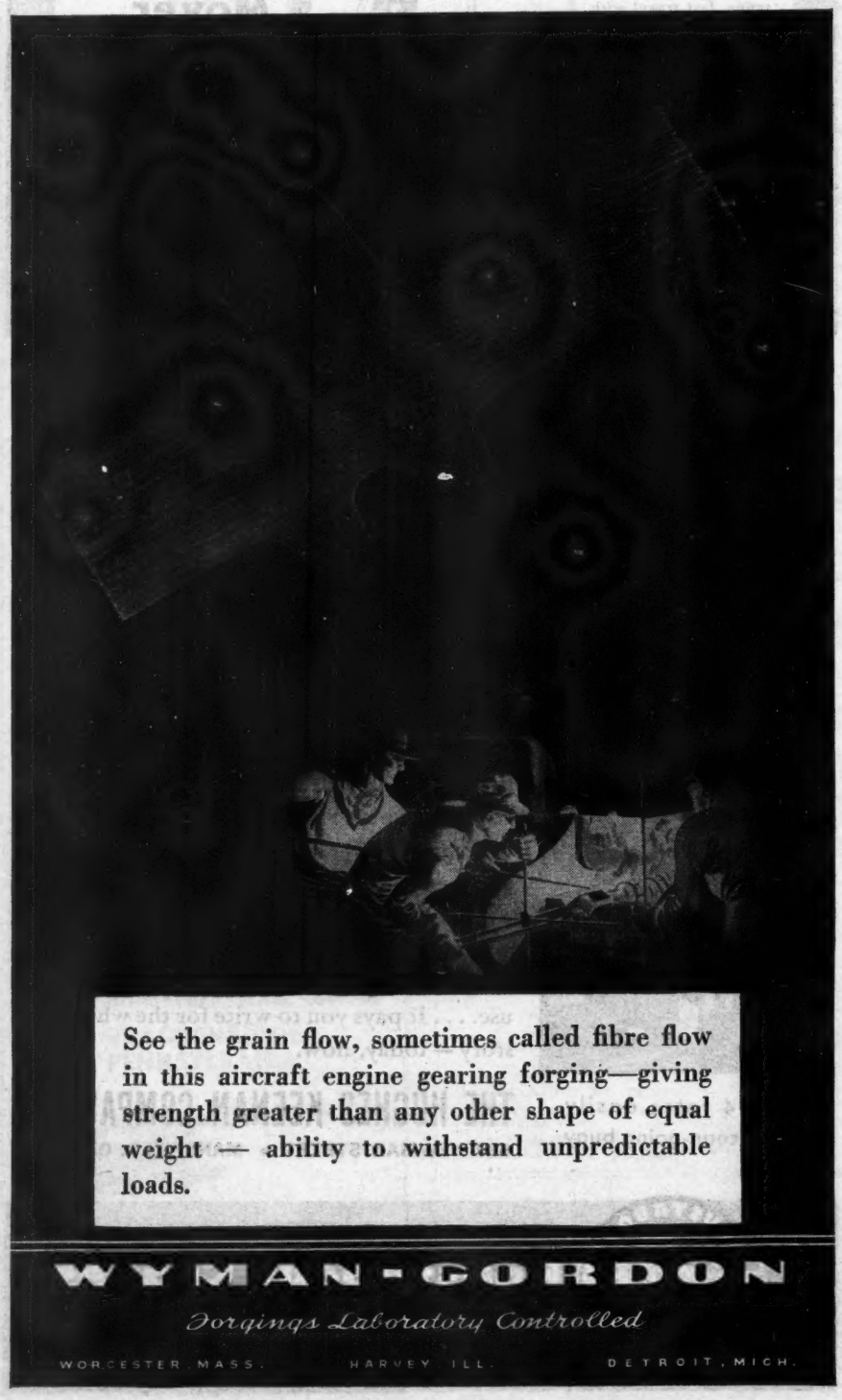
Among those tested, the only hose that satisfactorily met all requirements was the one having as a core a solvent-proof, rubber-like tubing of compar, a special type of vinyl resin developed by Resistoflex. As this limestone-coal-and-air derivative is entirely unaffected by hot dope, the contents are entirely uncontaminated by the compar. The hose, usually with synthetic rubber outer surface, can be dragged over the floor, pulled up to high surfaces, walked on, driven over by trucks, and in general subjected to gruelling abuse. One of these compar-core lines has been in use a year and it has shown no serious signs of wear.

The compar hose has $\frac{3}{8}$-in. i.d. and $\frac{11}{16}$-in. o.d. Each line is 50 ft. long, extending from the portable heating unit on the hangar floor to the highest control surface. A second line of the same length returns solution to be reheated. A pressure of 125 psi. is necessary at the start of operations when the hose is cold, but as the long line becomes heated, pressure may be gradually decreased to 60 psi.

Each hose can be used for all coats of dope—primary, intermediate, aluminized, and camouflage. Changing of sprays is easily accomplished by using a valve near the nozzle which permits the contents to drain back to the heating unit. Afterward, by increasing the pressure, the next solution is forced through the tube.

Although the outstanding characteristics of compar are its inertness to organic solvents and its wear- and abrasion-resistant qualities, its immunity to temperature extremes within a range of minus-70 deg. F. to plus-300 deg. is an important quality throughout the lifetime of the hose.

Half way between a synthetic rubber and a plastic, the compar is molded by techniques common to both the plastic and rubber industries. It is converted into continuous tubing by automatic extruders, the product varying in hardness, resistance to solvents, resilience, and translucence, according to individual specifications.


See the grain flow, sometimes called fibre flow in this aircraft engine gearing forging—giving strength greater than any other shape of equal weight — ability to withstand unpredictable loads.
WYMAN-GORDON
Forgings Laboratory Controlled
WORCESTER, MASS. HARVEY, ILL. DETROIT, MICH.

Marketing Plans

(*Continued from page* 121)

would be maintained (several manufacturers definitely stated that they would require this in their dealer contracts).

No light plane manufacturer was ready to commit himself on the point of greatest interest to most prospective distributors. That is none would state definite discounts or commissions to be offered dealers and distributors. This situation probably arises out of two conditions: First, the manufacturers do not know what the postwar economic conditions in the U. S. will be nor do they have much information on their postwar markets, since they have, apparently, made no extensive market surveys; and second, largely as a result of the first condition, they have not decided definitely on the different models of aircraft they will produce or the specific price fields in which they will sell.

A few concerns did, however, give probable commissions and discounts, with several indicating that the percentage, quite possibly, would be on a sliding scale based on volume of sales. The few figures given indicated average dealers' commissions of 15 to 20 percent and average distributors' commissions of 20 to 25 percent of list prices.

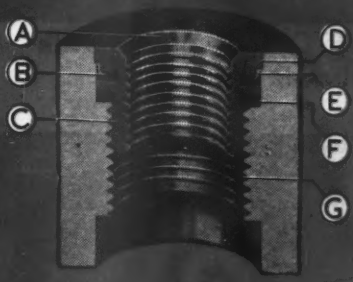
Those manufacturers who expressed themselves on the matter believed that there are at least three qualifications necessary for a successful distributor: (1) Knowledge of flying and the aviation industry; (2) adequate capital to enable carrying a few new planes in stock and also to handle used planes as trade-ins; and (3) knowledge of advertising, sales promotion, demonstrating, etc., since airplanes will definitely have to be merchandised in the postwar competitive market.

It is interesting to note that those manufacturers employing distributors in their scheme appear to want to place much of the sales help, promotional work, and other dealer aids in their hands. One company definitely stated that its dealers would work under distributors who would have full responsibility regarding such dealers. However, all of the manufacturers, though declining to go into detail, stated that their selling and promotional plans include national advertising campaigns on a broad scale, catalogs, performance sheets, envelope stuffers, and similar sales literature, as well as staffs of field representatives or regional sales managers who will devote their time to help dealers improve business.

This, then, is the rather incomplete picture of the postwar distribution set-up of the personal plane manufacturers. Since evidence indicates strong competitive conditions in the postwar era, it would behoove those manufacturers who have as yet made no distribution plans to do so at once; and they, as well as the other manufacturers, should quickly begin to attract the best qualified distributors and dealers, and locate them in strategic areas.

Of late, there have been many fanciful predictions concerning postwar private flying, with unrealistic visions which may unintentionally become a menace to the

HYDRAULIC SEALING IN SOFT MATERIALS



A Champfer for Standard A.N.D. Seal.
B Counterbore, the wall of which is broached by the Rosán Locking Ring D.
C Rosán Hydraulic Seal Insert.
D Rosán Locking Ring.
E Chip peeled from the wall of the counterbore by the outer splines of the Locking Ring during broaching process.
F A. N. No. 902 Synthetic Rubber Ring for sealing.
G Standard Threads.

ROSÁN
U. S. and Foreign Pats. Pend.

THE ROSÁN HYDRAULIC SEAL INSERT

Seals
10,000 POUNDS PLUS

This Rosán Hydraulic Seal Insert is the newest development of the Rosán Locking System for threaded inserts and studs in all materials. By use of this insert, a fitting may be screwed into a port in soft metals and completely sealed under pressures far beyond test specifications and normal safety requirements.

It has been tested to 10,000 P.S.I. (the limit of the testing apparatus) without leakage or failure of any kind.

Again the Rosán Locking System has solved a problem of fastening in soft materials. The Hydraulic Seal Insert is locked firmly in the parent material by the serrated Rosán Locking Ring which prevents turning; and the fitting can then be installed in a steel unit instead of soft metal. Crossed threads are thus unlikely to occur, but in case of damage the insert is easily removable and can be replaced without special operations.

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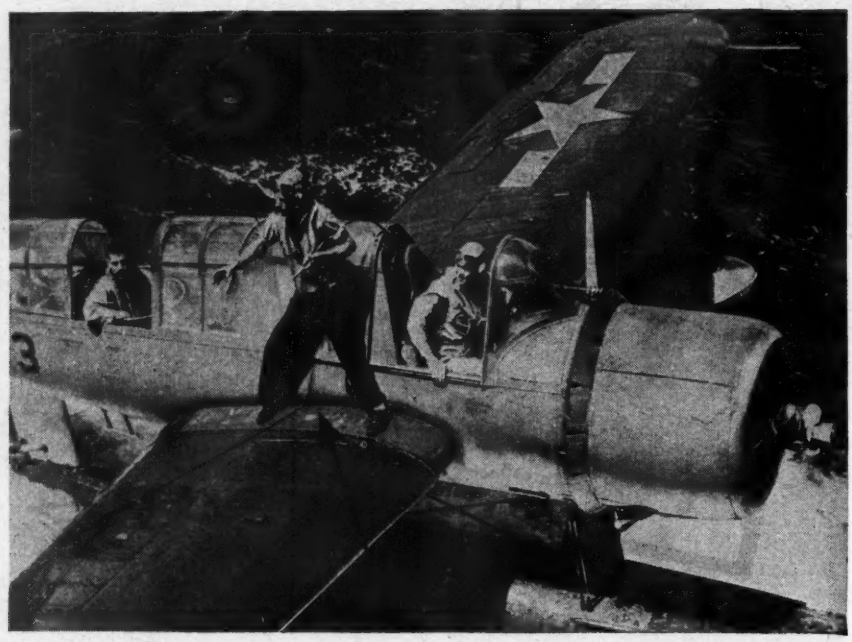

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HE CANNOT SLIP EVEN ON THAT WET AND PITCHING WING

● Catching the hook that will hoist this Kingfisher float plane back on its ship, with the plane plunging and pitching in a choppy sea, would be a hazardous assignment without a safe, non-skid wingwalk.

WETORDRY Safety Walk has a tough, non-skid surface which bites through water, mud, oil, or grease to give sure footing under the very worst conditions.

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personal plane manufacturers, being likely to convince many people that the moment hostilities cease, they will be able to buy a shiny red helicopter with pastel colored upholstery or a silvery, high-speed sports model plane for a paltry "thousand", and soar blissfully into the sky. Such persons will probably be disappointed, for no authoritative source paints such a rosy picture. And disappointed aviation enthusiasts won't help the manufacturers' eventual marketing problem.

Parks Air College has recently attempted to ascertain the extent of the postwar personal plane market by a field survey. The conclusions reached in this study (See article "The Personal Plane Sales Target," page 116 Jan. '44 AVIATION) were that an indicated 78,000 financially able Americans plan to pay at least $1,500 for a postwar personal airplane as soon as the craft is available; 119,000 are ready to buy helicopters; another 78,000 are potential aircraft customers who will buy either helicopters or airplanes; and that these groups represent 1, 1½, and 1 percent, respectively, of the financially able 6 percent of the population who may be unqualifiedly considered sound sales prospects. These conclusions were based on answers to questions asked of 1,000 financially able persons variously located in nine large eastern, midwestern, and southern cities.

In the opinion of many, this picture is overly optimistic, at least for the first few years after the war. The results of another study (See article "Let's Be Practical About Postwar Plane Markets," page 114 Dec. '43 AVIATION) seem more realistic even though this estimated market potential covers only the first two years following the cessation of hostilities. (A longer period of time was not covered for it was believed that design and production changes are unpredictable at this early date.)

According to this latter study, a total of 9,500 new planes will saturate the market during the first two years after the war. This seems reasonable when it is recalled that before the war there were 13,406 available planes that could be grouped in the personal plane classification. By applying a 20 percent attrition rate to these planes, which have had extra hard wear in the CAP coastal patrol, courier services, and training programs during the war, it may be assumed that we will have 10,725 used planes in private hands at the end of the war.

This figure plus the estimated 9,500 new planes gives a total of 20,225 personal planes to be distributed over the first two postwar years.

Many persons have exaggerated their ideas of the postwar personal plane market by overestimating the market potential of our 2,500,000-man air forces. None of these men is getting rich, despite flying pay. Most plane manufacturers do not consider a man a good airplane prospect unless he has an annual income of at least $4,000. Since only colonels and above receive that much pay in the army, it can't be assumed that the greater portion of air forces personnel will be good prospects immediately after the war; nor is it

likely that many will return to peacetime jobs that will put them directly in the $4,000 income bracket. Then, too, many of these men will be automobile prospects before being airplane prospects.

Another factor which a great many people have overlooked is that a large number of the men in our air forces do not have the interest in aviation that they are assumed to have. Surveys have shown that up to 25 percent of the men questioned profess no interest in any kind of postwar flying.

Another factor which tends to dampen optimism for a large postwar plane market is the competition the personal plane manufacturer will encounter from other manufacturers who are ranging their sights on the consumers' dollars. The public will more than likely spend its postwar cash for the things it considers "necessities"—automobiles, refrigerators, radios, etc.; and the personal plane will not have attained, during the immediate postwar years, this status of "necessity" in the American public's mind, though it may do so in the not too distant future.

There have been, thus far, three main obstructions to a major increase in private flying: Lack of utility, price, and fear. The lack of utility can be attributed in part to over-regulation, but perhaps the main reason is the lack of adequate and convenient landing and servicing facilities. To overcome this obstacle, airminded America must sponsor movements for good airports just as automobile enthusiasts sponsored the good-roads movements leading to our present highway system.

Many state highway departments have collaborated with the federal government in planning systems of flight strips. Some flight strips have already been built, and undoubtedly many more will be constructed after the war as, perhaps, a part of a government program to facilitate conversion from wartime to peacetime economy. But civic organizations, such as the chambers of commerce and other organizations and persons interested in aviation, should actively promote the construction of community landing fields and service facilities for the use of private flyers. Government regulation in the public interest, but kept to a constructive minimum, should also be sought.

The obstacle of price can be overcome only through development of design and mass production. With technical developments and increased fuel efficiency, costs of plane operation should be materially reduced.

Natural fear of the air must be overcome by the development of aircraft which have ease of control and inherent stability. These are the aircraft characteristics which will enable anyone with normal intelligence to fly his plane with ease and with assurance.

In view of the many hindrances and problems, both technical and psychological, concerning the postwar personal plane market, it is certain that a wisely planned, vigorously executed campaign must be undertaken by the manufacturers and other interested individuals to *sell* aviation before the *airminded* American public becomes the *flying* American public.

a Breather

FOR HOT PLANES AND MEN

Heat—140 degrees, and more—
maintenance crews in plane interiors, oven hot.
Portable ventilating units, powered by gasoline engines,
bring relief—draw hot air out, or shoot cool air in—
one more war job for dependable Briggs & Stratton
4-cycle air-cooled gasoline engines.

Air-Cooled Power

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

During 25 years of *continuous* production Briggs & Stratton has built more than 2,000,000 air-cooled 4-cycle gasoline engines. We are now well started on the 3rd million. Their trouble-free performance, easy starting and economy have made Briggs & Stratton leaders in the field—"preferred power" everywhere.
BRIGGS & STRATTON CORPORATION, Milwaukee 1, Wisconsin, U. S. A.

From this discussion it will be seen that there are several developments seemingly needed if private flying is to offer a mass market for light plane manufacturers. These are:

(1) Planes suitable for cruising in the hands of amateur pilots, selling for prices comparable with automobiles, and with low operating costs. Manufacturers assure us that such planes will be available.

(2) A new system of airports for private flyers, particularly airports around larger cities. Several hundred automobiles can be parked on a lot at the same time, but two planes arriving at the same airport simultaneously create "congestion." It seems most undesirable to attempt to use the same airports for commercial planes and private planes.

(3) A system for ground servicing private planes, sufficiently extensive and economical to permit people in moderate circumstances to use it.

(4) A program of marketing which will sell planes for individual use to people who are not already determined to buy. It seems almost unbelievable that manufacturers apparently have not given more thought to making it possible for the-man-in-the-street to buy a plane with a favorable minimum of inconvenience.

(5) A system of instruction which will permit a person interested in flying to learn to pilot a plane without spending too much on instruction and without too much interference with his or her work.

Without these developments it appears unlikely that private plane ownership will become general enough to develop a very large market. Of course, even under conditions as they were before the war, people with money and leisure will tend, in increasing numbers, to fly. But a small custom-built market, something like the postwar motor boat market, is not what the light plane manufacturers want. They need a mass market able to support large scale manufacturing.

The responsibility lies with the manufacturers—(1) Will they have marketing plans ready when the war is over?; (2) will they have a distributor set-up or will it be a scramble?; and (3) what are they doing to be ready?

From the results of the survey referred to in the first part of this discussion, the answers are: (1) No; (2) probably the latter; and (3) surprisingly, little if anything!

But private flying *will* develop if the public wants it and manufacturers are ready for it.

FACTS YOU SHOULD KNOW
about
HARD Chromium Plating

Chromium electroplating was first accomplished by Bunson in 1854, while Geuther in 1856 succeeded in electroplating with chromium from a chromic acid solution which is the method in general use today.

Until 1935 chromium plate was principally used as a decorative coating. This coating was very thin (.00002") and was used on many articles because it retained its lustrous beauty by resisting tarnish.

Not until we entered the war did "*hard*" chromium plating become an important factor in the tool industry, for it was quickly discovered that coatings from .0002" to .05" thick would conserve steel by greatly increasing the life of hand and machine tools and make fabricated parts last longer.

Most industrial coatings of chromium plate were found to have a value of 1000 Brinell with No. 9 position on the Mohs scale, with the diamond as No. 10. This extreme hardness was found to outlast the wearing qualities of hardened steel gages by 5 times.

That is why all Ellstrom made gage blocks are chromium plated on their gaging surfaces—to give them wearing qualities that will outlast the life of the ordinary hard steel blocks.

By actual test Ellstrom standards will last 2 to 5 times longer.

★ This is number one in a series of articles by the Dearborn Gage Company on chromium plating. ★

DEARBORN GAGE CO. 22035 BEECH STREET DEARBORN, MICHIGAN

Originators of Chromium Plated Gage Blocks

Robot Engine-Tutor

(*Continued from page* 195)

are pilot's switch panel, including ignition, battery, fuel booster, electric primer and starter switches; a throttle and mixture control; and a tachometer. Terminal strips and connectors complete the systems, which have visible wiring so students can trace and study the circuits.

As illustrated in Fig. 2 showing the rear of the panel, the magnetos are driven by means of pulleys and belting from the 110-v. mockup "engine". Speed of the latter may be varied by shifting the movable brush housing, this being accomplished by the throttle control on the front of the panel via mechanical linkage of push rods and bell cranks.

Completing the installation at the rear is the "electrical brain" consisting of 5 micro switches and 24 assorted relays, including 4 agastat time-delay relays.

Completing the front of the board, but somewhat inconspicuous until a boner is pulled, are two flush lamps with apparently blank opaque lenses, and a 3-in. toy propeller mounted on a front view airplane silhouette.

All cadets are given practice in starting and in preflight checking on the mockup, to tie together various facts that they have learned in previous study of the individual units of the systems and to prepare them for starting engines later in the maintenance engineering course. The sequence of operations on the mockup must be exactly as outlined in Technical Orders, else the engine will not start. And in the event of a serious error of omission or commission, a mild pandemonium breaks loose.

After the toy propeller is turned (igni-

tion off), the engine will start if remaining procedure is correct—that is, cutting in battery and electric fuel booster pump, energizing starter, priming, turning on ignition, and meshing starter to engine. The mixture control must be in idle cut-off or the engine will be "flooded" and not start. During meshing, the starter rotates engine and magnetos slowly, and the student may observe how the hot booster spark fires one row of sparkplugs.

After a short time the 110-v. power takes over, the engine speeds up, and the magneto sparks fire both rows of sparkplugs. Within a few seconds, however, the engine will begin to die if the mixture control is not thrown forward to auto-rich. The start completed, the engine now runs as long as ignition and mixture control are "on", regardless of battery and fuel booster switches.

If the student does not first turn the propeller, the engine will never start. Instead, upon being cranked, a loud clatter (muffled bell) results, to simulate the sound of a broken connecting rod thrashing around in a crankcase. This scares the student into releasing the starter switch; the noise stops but it is too late—the damage is done. One of the seemingly blank lenses on the panel then becomes illuminated, outlining this message:

SNAFU!
1 ea. Engine at $20,000
is now
1,500 lb. Scrap at 29c. lb.
because . . . . . ?

To provide, simultaneously, a gentle hint of damage caused by failure to observe prescribed precaution, a small board, hitherto hidden below the table top, is automatically released by an electromagnetic latch and swings out on hinges towards the student. Fastened to the board is an actual bent connecting rod salvaged from a ruined engine. With this mute but vivid evidence before his eyes, there is no need for extended lecturing or preaching.

Regardless of position of the other controls, if a student turns the propeller while the ignition is on, the engine immediately starts. Simultaneously a piercing siren (landing gear warning horn) shrieks for about 4 sec., startling the "decapitated" cadet half out of his GI shoes. And the other blank lens now flashes—

There goes the ambulance
for another GI mechanic (?)
who forgot
that the
ignition was on!

If the mixture control was out of idle cutoff, the engine keeps running until shut off by either the ignition switch or fuel cutoff. If the control was in idle cutoff, the engine kicks over for just a few seconds and then stops, since the "small amount of fuel present is burned up". In any case, the damage is done, and the

NOTE:

This "quick change" chuck has a wide field of application . . . adaptors can be loaded with all sizes of drills, . grinding quills, screwdrivers, countersinks, reamers.

•

Of course, its big use is for drilling . . . takes drills down to a 1" stub!

•

That means a big saving in both money and drills.

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Savings on drills alone pays for chuck changeover in a very short time.

•

Have you one of our catalogs? →

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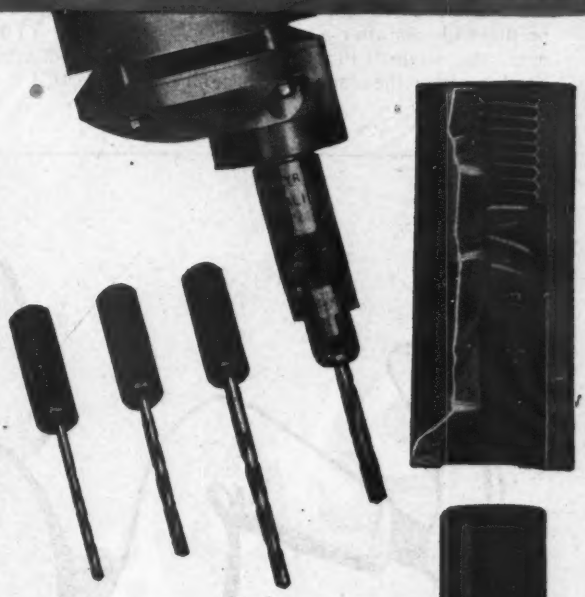
Uses Broken Twist Drills
No Key Required . . . Saves Time



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students may ponder on the not very funny possibilities on a real airplane.

One naive student asked, "Where is that warning light on airplanes?", to which a more experienced classmate replied, "By that time, mister, it is already too late!"

Both of these "gag" effects are so startling that students do not forget them, which is just what is desired.

Apart from stressing these two dangers, the mockup serves for practicing certain preflight checks after a start. At correct rpm. the student turns off ignition to check whether the magnetos cut out, causing engine to slow down. If the switch is turned on again before engine has completely stopped, the engine will regain speed as magnetos resume firing; if not, complete starting routine will again be required.

Next, setting the prescribed rpm. by means of the throttle, the student switches to left magneto and to right magneto. He observes that one row of sparkplugs cuts out and that speed slackens, the tachometer showing a decrease of about 100 rpm. (This is accomplished by a relay that inserts resistance in the 110-v. motor circuit.)

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Although the engine may be stopped by turning off the ignition, students are taught to do it in the prescribed way by pulling the mixture control back to idle cutoff. Then, after a second or two, the engine begins to die, the magnetos still firing to the end.

The mockup enables the instructor to demonstrate another danger. In magneto ignition systems, the ignition is on if the wires from the magneto to the switch are open-circuited, regardless of the switch indication. On this mockup the magneto primary and ground wires terminate in a connector plug (as they do on most airplane installations) which mates with a receptacle on the front of the panel (actually on the firewall of a real installation). If this plug is disengaged, no matter what the switch shows, the ignition is "on"; the engine may start, or if already running, can only be stopped by shutting off the fuel. (Sometimes a gremlin loosens the plug by an inconspicuous amount, and lets the puzzled students trace out the trouble.) A special grounding-receptacle is also provided, as found on some engines. If the magneto plug is inserted there, the engine cannot start or run, regardless of switch or control manipulations.

The effects of turning the propeller and priming are good for only one start. After that start, a relay mechanism automatically resets the system so that the next student must follow through the complete starting routine.

In addition to the foregoing operating uses of the mockup, students also use it for conventional purposes, such as inspection, test and adjustment, and installation of individual units.

Students in the maintenance engineering course at the AAF Technical School at Yale frequently include experienced pilots or mechanics, and these men generally start the mockup engine in short order. Pilots may forget to turn the propeller over beforehand, which is understandable, since this is actually the mechanic's duty. Nevertheless, all personnel learn that it is a "must".

Students are sometimes nonplussed by the number of switches and controls confronting them (a modest array compared to what they will find in a cockpit). To conquer this feeling of confusion is one purpose of exposing them to the mockup. They may be a bit shaken when they pull a serious boner and get the electric "razz", but they laugh it off and insist on practicing the procedure until they have mastered it. (Then they want to watch the next fellow try it and get the same sort of treatment.)

Col. R. J. Reeves, C. O. at Yale, himself an experienced pilot, has frequently tried his hand on the mockup, and he has demonstrated it to various visiting and inspecting parties, including Lt. Gen. B. K. Yount, Commanding General, AAFTC and Maj. Gen. J. E. Fickel, C.G., AAFETTC, who have commented on it with enthusiasm.

The most "shocking"—literally—feature of the mockup remains to be described. One observation was that many students keep the finger on the starter switch even after the engine starts and

picks up speed, something they would never do with their foot in an automobile. The starter switch (like that of an auto) springs back to "off", merely by release of finger pressure. With failure to release it, the result is the same as in an auto: The dog on the rapidly rotating engine shaft rides roughshod over the teeth of the mating dog on the slow-moving starter shaft. Aside from the clatter, this is not too serious, except that in time the teeth on these dogs may be stripped. This being no way to treat even a dog, this little sign is posted next to the starter switch:

When the starter "dog" begins to bark
Let go the switch, or he'll bite
(and you'll be sorry)

And to put some force behind this appeal, a circuit is established (by means of a special "gremlin" relay) some 5 sec. after the engine starts, provided that one's finger still depresses the starter switch. This circuit leads to a spark coil, whose output is fed to the metallic switch handle.

. . . But so far, no one has failed to release the starter switch in time.

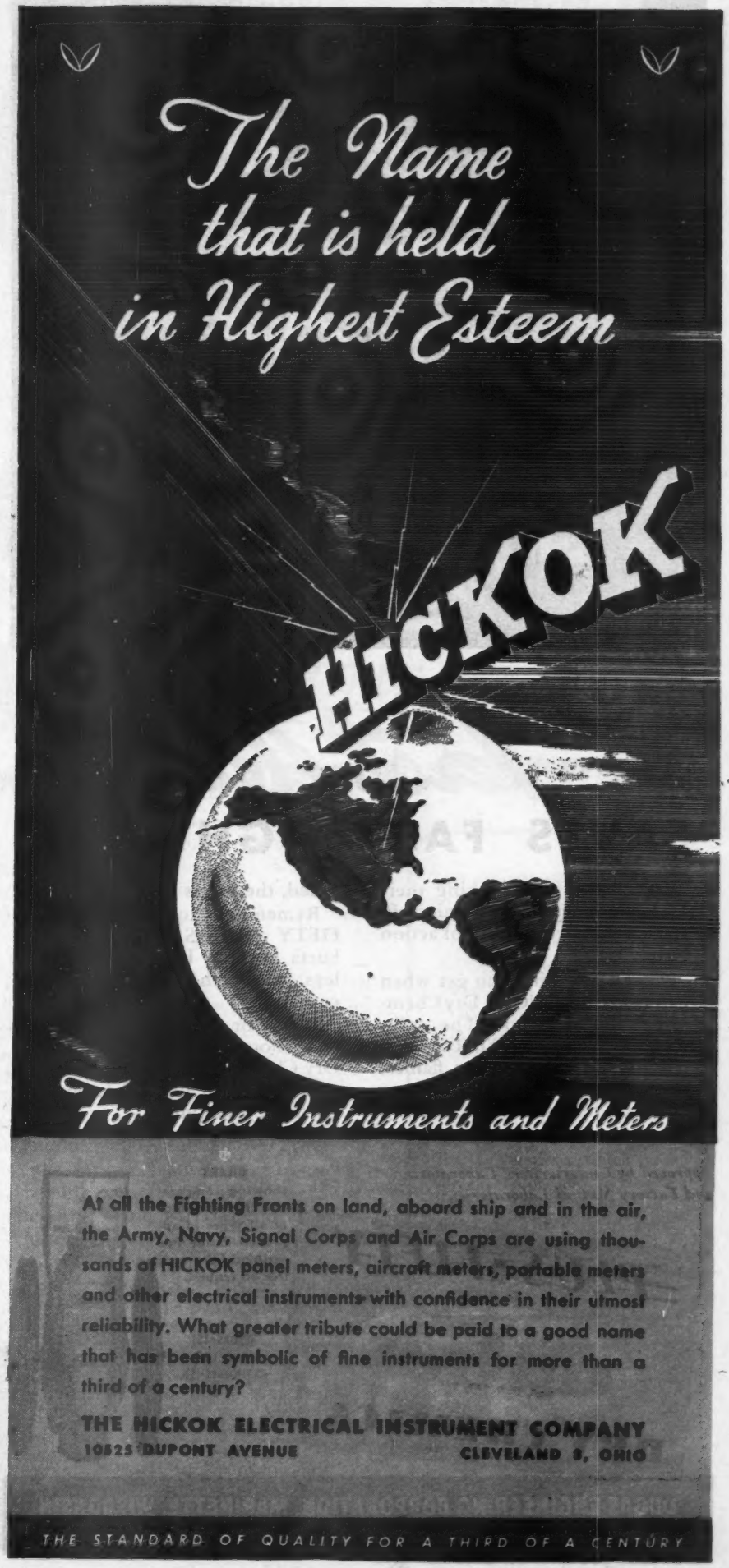
Pattern for Traffic

(*Continued from page* 193)

The most effective provision for safety under the two-pattern condition, however, is the local rule requiring take-offs to be made down the middle of the field (next to dividing line) while landings are made toward the outside of the field thus separating landing lanes and base leg of each pattern by half the width of the field. Since takeoff is easier for the student, he has more time to concentrate on other traffic than he has during landing, when his attention is completely absorbed by problems of drift correction, leveling-off, and keeping from ground-looping. Thus it is believed much safer to have takeoffs from both patterns close together rather than the landings.

When two-way traffic prevails, Hawthorne Field is divided in half by a "no-man's land" designated by dual pyramidal markers, additionally marked by large red and white flags. The line between the markers on opposite sides of the field, roughly splits the field in half and leaves a strip 200 ft. wide the length of the field, in which no aircraft is allowed to land or taxi.

To simplify pattern flying and to help students become acquainted with landmarks associated with various traffic pattern headings, there are only eight tee settings. These settings are north, northeast, east, southeast, etc. Under average wind conditions, only four patterns are used to great extent. Most of the time prevailing winds allow a west or southwest setting, and because the tee is never varied even slightly to allow for minor cross-wind conditions, the students and instructors can quickly familiarize them-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selves with specific landmarks to enable accurate pattern flying.

Frequent Cross-Wind Landings

While the use of only eight patterns resulted in slight cross-wind conditions, it has been felt that better safety is achieved by standard pattern headings than by landings directly into the wind. There is also the additional training advantage of familiarizing students with cross-wind conditions early in training, an asset which will help them later in combat operations off rough and narrow one-way strips.

Students find pattern flying extremely difficult at first, due to inability to visualize either the size or proper direction of the pattern. Despite the large size of the tee, its heading is sometimes hard to determine even for old-timers when flying in the down-wind leg (½ mi. from tee). To help orientate students, an accurate drawing of the field and surrounding territory was developed by army, ground school, and flight department members, and placed on a large 10 x 10 ft. table near the lower class ready-room. All details, such as highways, silos, fields, rivers, and streams in the vicinity of Hawthorne Field are marked accurately on the map, and a miniature tee, which can be set according to conditions of the day, is used.

This device, instituted several months ago, has done much to improve new students' ability since it enables them to study the pattern carefully before getting in the air. As a further training aid, aerial photos of the field have been mounted on the ready-room wall with the pattern for each tee-setting superimposed on the pictures.

The dual-pattern system is only used when the tee is set either north-south or east-west. Due to the roughly rectangular shape of the field and position of buildings on the north side, two-way traffic under diagonal (northeast, southwest) conditions is not practicable. Under such conditions, a single pattern is flown and in a direction which keeps the aircraft away from the cantonment.

Direction of traffic is indicated by the yellow arms at the windward end of the tee. Either of the arms may be folded back when one-way traffic is desired, or both may be closed—an indication that flying has been called off.

Accurate Flying Necessary

Strict compliance to direction of traffic on landing and takeoff is, of course, the main factor of safe pattern flying under the concentrated activity at Hawthorne. Variations of even 5 deg. are not tolerated by instructors or the airdrome officer who is in the tower checking traffic movements at all times.

To enable students to land and takeoff "on the tee", eight 600 ft. lime lines, intersecting in the center of the field and aligned with the eight tee settings, have been laid down. Visual reference to these long lines make it very simple for a student to make his final approach, or climb after takeoff, properly aligned with the tee.

The most awkward moment in the course of the field's busy flying day occurs when a tee change is necessary due to pronounced change in direction of the wind. Responsibility for the change lies with the airdrome officer, who normally waits until he is sure no cadets on their initial solo flights are in the pattern. In the past, some close calls have occurred when students, shooting landings off the south side of the field, failed to notice a tee change (tee is on north edge) and took off 90 deg. to the new tee setting.

To avoid this and other contingencies, a pre-takeoff check has recently been ordered. This includes checking of the tee direction, both magnetos for "on", and "clear behind, clear ahead." This check is made at 45 deg. to the tee, in which position the plane must be parked until actual takeoff is started. To insure minimum parking at the end of the runway and to avoid a recurrence of the accident previously mentioned, magnetos are now checked while planes are still on the ramp.

Accommodation of so much traffic necessitates takeoffs only a few hundred feet to one side of a plane which may be landing, and also requires takeoffs in rather quick succession. The rule followed is, "Wait until plane ahead has left ground before starting your takeoff."

At 8:00 a. m. (when morning flying starts) and 1:15 p. m. (when afternoon flying starts) the rule is altered to speed getting planes, especially dual planes, in the air. For the first few minutes, the center-field takeoff ruling is not applied and dual ships may takeoff, with the tee, from any point and in reasonably close succession. No planes are allowed to land until the initial rush is over. It takes about 20 min. to empty the ramp.

Uniform Taxiing Important

Systematic handling of aircraft on the ground is no less important than control of aircraft in the pattern. A set of rules which are both simple yet effective is something which only experience and trial-and-error can develop. The ground rules now in effect, however, represent workable and practicable safety measures commensurate with fast and efficient handling of aircraft.

The one criterion which predominates is that taxiing accidents are inexcusable, and severest disciplinary action is taken in cases of negligence of this sort. To encourage safe flying and ground handling, a contest between squadrons, based on a point system, has worked out well. To illustrate the serious vein in which taxiing accidents are treated, a ground-loop rates 2 points against a squadron, a nose-over (which sometimes results in serious damage) costs only 5 points, yet the smallest hole ripped on a boundary marker rates 10 points, the same number assessed for mid-air collision, which has never occurred at Orangeburg. The only offense considered more serious than this is the low-flying violation which is valued at 15.

This point system has done a great deal to reduce accidents of all varieties, and squadrons (consisting of 30-40 students

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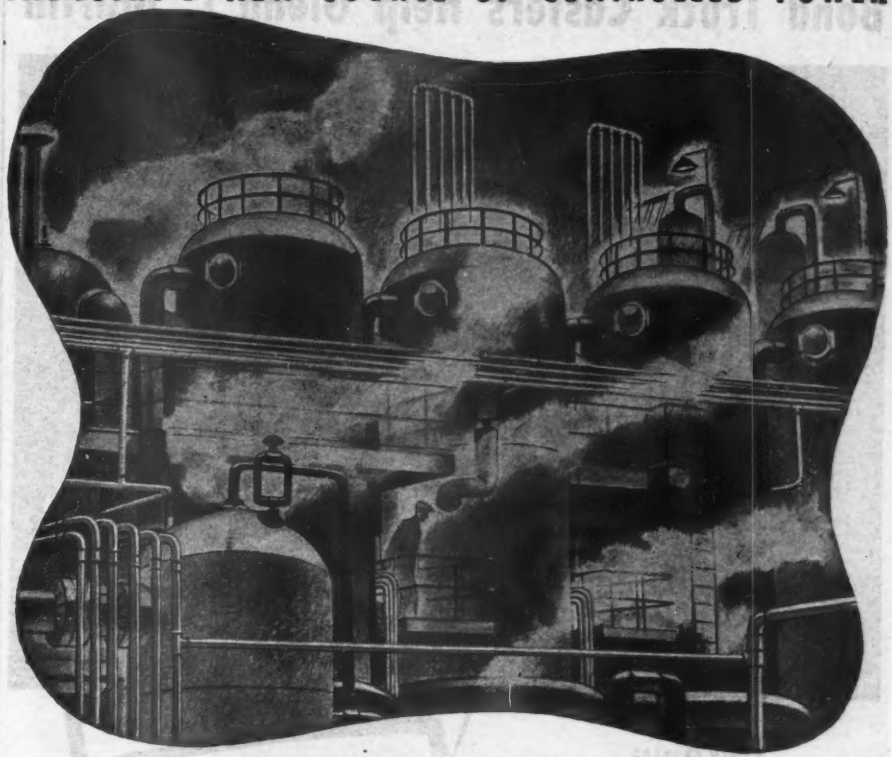

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flying from 2,000-2,500 hr. each class) have won the prize with as little as 11 points. (Points are charged whether or not the offending plane is damaged.)

Taxiing on the ramp is not allowed unless there is a man at each wing tip and the speed no faster than a brisk walk. Away from the ramp, faster taxiing is permitted, but continued "S'ing" is required to keep the area ahead cleared.

Taxiing to takeoff area and back to the line is always done along the boundary of the field and in the direction of traffic. That is, if the pattern is being flown to the left, traffic on the ground moves only to the left. Taxiing traffic moves in a single line, and passing is not permitted.

After landing, a plane may turn off the landing area only in the direction of the traffic pattern. Thus if the pilot has landed from a right pattern he may only turn to the right and then 90 deg. to get off the landing area as fast as possible. Since the planes are landed near the outside of the field, a minimum amount of taxiing is needed to get to the edge.

A turn against the tee is permitted only after the plane has been taxied straight ahead to the up-wind edge of the field and then only if the pilot is returning to the ramp at the end of the flight. This rule permits landings in reasonably quick succession since the pilot can choose a landing lane outside of a plane ahead and land fairly close because he knows that the lead plane will only turn away from his landing lane.

As much as possible, ships are required to trail in the down-wind leg of the pattern and to widen the interval between planes by throttling back if necessary. Worst etiquette is for a pilot, entering traffic, to establish his down-wind leg behind and inside a plane already in the pattern. This tends to bunch the two in the base leg.

If a ship overshoots and must go around, the pilot must climb straight ahead to 600 ft. rather than 400 ft. where he would normally make his first pattern turn. This avoids the possibility of a ship taking off at the same time and climbing up under the overshooting plane. Collision of two planes under such circumstances at another school led to the adoption of this rule in the Eastern Training Command.

All landings must be made in the first half of the field—a rule rigidly adhered to.

The airdrome officer is on duty whenever flight operations are underway, and this duty is performed by supervisory personnel only. From the vantage point of the tower, the A.O. keeps an eye on takeoffs, landings, and pattern flying, and he reports in his daily log the ship number, pilot's name, and time of any infraction of rules, such as cross-tee takeoffs, scraped wings, ground-loops, poor landings, etc. Solo students who are observed flying improperly are called to the tower and reprimanded right on the spot.

An innovation which has proved very helpful is the assignment to tower duty of two lower class cadets on 2-hr. shifts. These students remain by the side

of the A.O., note errors in pattern flying, and from the elevation of the tower gain a clearer conception of the pattern and how to fly it.

The tower is equipped with a standard airport light-gun, which is used for emergencies and to call planes back to the line. It has not been found necessary to use the green light to signal each takeoff or landing.

Successful handling of traffic at Hawthorne and other civilian contract schools, as well as WTS schools with large fleets, indicates that use of the rectangular pattern is the most satisfactory method of keeping heavy airport traffic under control. In a training operation where rigid discipline can be enforced it is an ideal solution because precision of altitude and direction is required and attained to a fair degree.

With civilian operations involving transients who are inexperienced with local regulations and patterns, pattern flying can get pretty sloppy, but at least it provides some uniform handling of traffic.

Which leads to the inescapable conclusion about airport flying—that no condition is ever safer than the degree to which the pilot will look around. In military flying, the pilot's life largely depends on seeing the enemy first, hence the eagle-eye is stressed to the *n*th degree in the army's training program.

And it can be no less important in future civilian operations, for collision is seen as a main hazard in the postwar days when more airplanes than ever will be taking to the skies.

What you see first won't hit you *if you see it soon enough.*

Calculating Flap Weights

(*Continued from page* 155)

true, since a becomes equal to zero—

$$w = k\frac{PL^2}{h}$$

This indicates that the weight per square foot varies directly as the loading and cube of length; and inversely as height.

Empirical Verification

Validity of the expression may be determined by actual trial on existing flaps. This check must be made on similar designs to conform to the basic assumption that the ratio of bending weight to total weight of flap is a constant. The degree of similarity of the two flaps will determine the magnitude of final resulting discrepancies. Therefore, careful consideration should be given to all variable factors involved in both designs. The writer's experience has shown that the error to be expected is usually within a range of values from plus 10 percent to —10 percent. A variation of this magnitude is permissible in preliminary estimates of structural groups of large proportions.

It is to be remembered that the expression developed does not include any balance weight when applied to ailerons. Only the structural weight was considered

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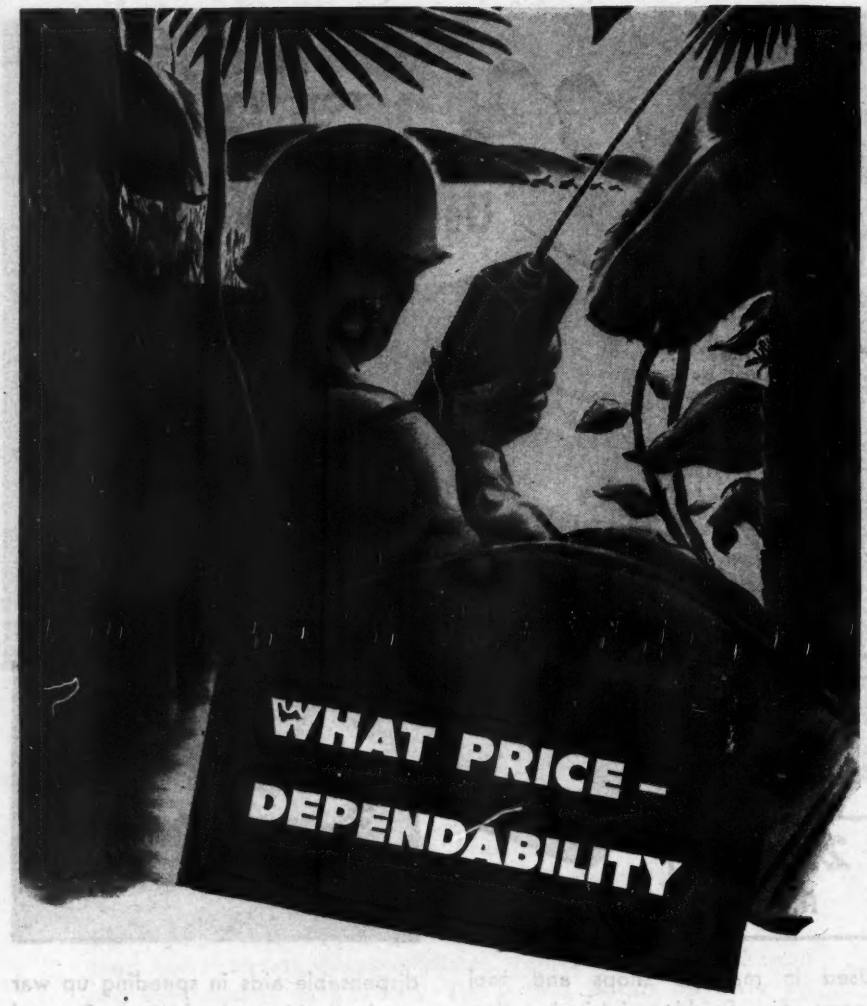

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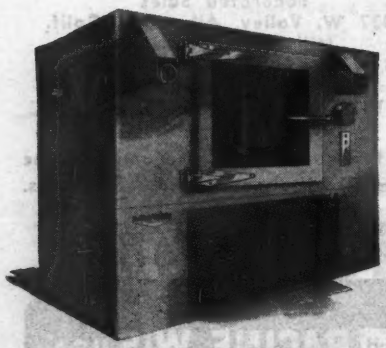

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in the derivation. The estimation of necessary balance weight is a function of degree of static balance required and amount of aerodynamic balance desired. A complete review of these factors will aid greatly in ascertaining amount of balance weight necessary for the aileron.

Best method of estimating balance weight is to compute static unbalance by assuming a C. G. position for the structural weight. Then, dividing this unbalanced moment by the arm to the expected position of balance weight will yield the amount of necessary lead. Total estimated weight of flap is then equal to the sum of structural weight and balance weight.

Application

To apply the derived expression to best advantage, it is necessary to determine the k bending constants, from many previous designs and record them in tabular form according to type of flap, construction, number of hinge supports, material, and geometrical properties. With this complete data readily available, it is simply a matter of selecting the proper coefficient to be used for the new design. The coefficient is selected from that flap which most closely resembles the new design. Substituting this value in the weight expression together with the pertinent data describing the new flap, the weight may be easily estimated.

This analysis presents a general rational expression that may be used to estimate the weight of a flap or aileron, based upon structural considerations. Results obtained are within allowable limits of accuracy permitted for weight estimation. As a check, the value computed by the equation should be compared to the figure calculated by conventional method of unit weight multiplied by area. For final estimate, the average weight as determined by the two methods may be used reliably.

What Price Stocks?

(*Continued from page* 206)

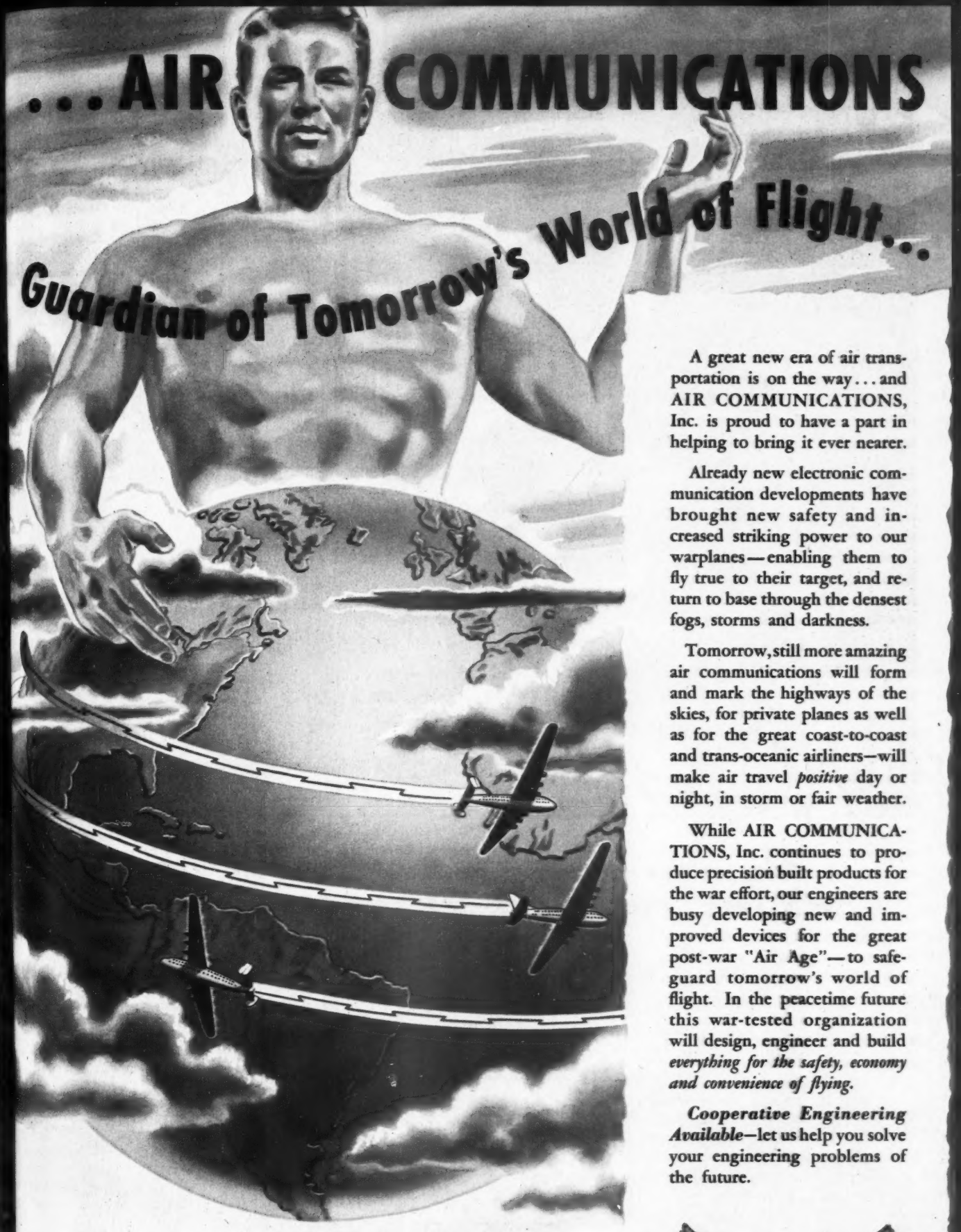
the case of companies making equipment used in the Pacific area.

As war contracts are cancelled, Donald Nelson, chairman of WPB, has told the industry his agency will determine, first, if other war work may be given to a company, then what essential civilian production a firm can handle, and next, if essential materials could be allowed the firm for non-essential civilian production.

There will not be a recurrence of the abrupt cancellation like that on the Brewster contract, Nelson has assured Congressmen. But, he also emphasizes, the solution of the industry's reconversion problem rests primarily on the initiative of management.

It may be that the government will be able to hand a big housing program to whatever segments of the industry are interested a little later on. At least, the Foreign Economic Administration is known to have undertaken an inquiry into the feasibility of placing orders for

(*Turn to page* 297)



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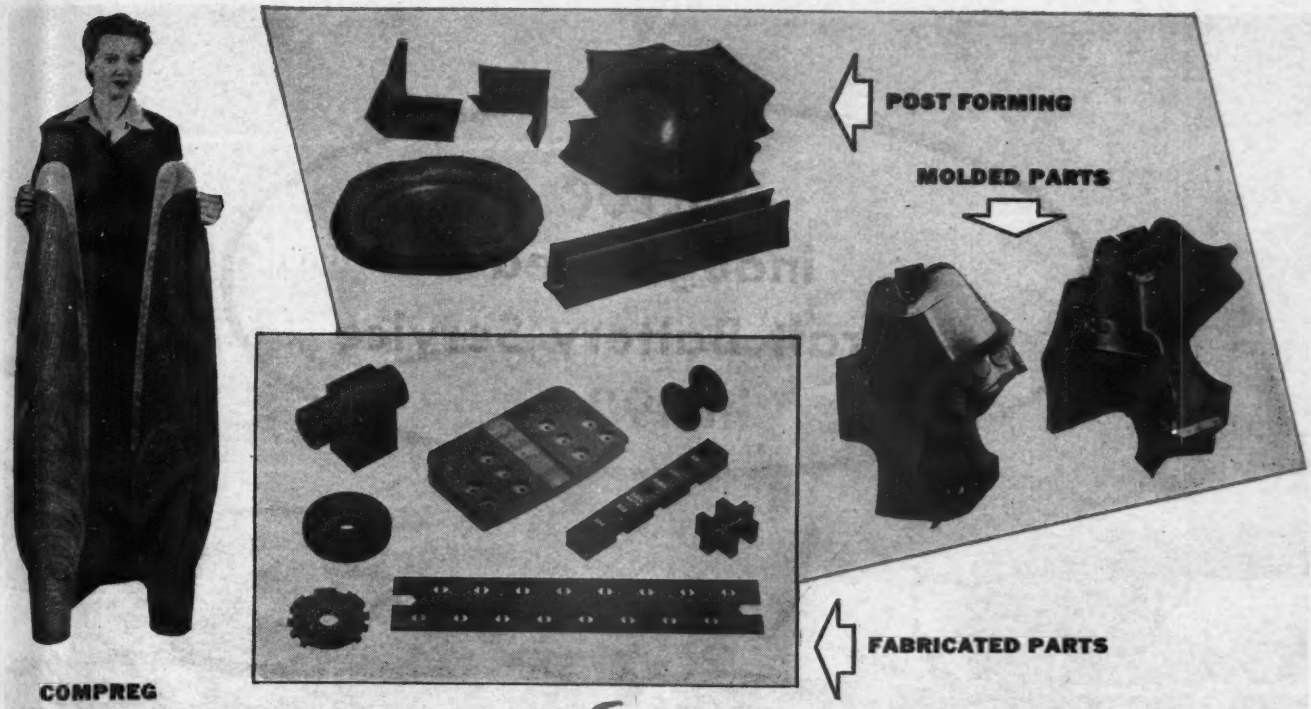

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The nationwide organization of the Panelyte Division is a clearing house for authentic, up-to-the-minute information on structural laminated resinous plastics.

Our replies to your inquiries are founded — not on theory — but on basic experience in the mass production of fabricated and molded thermo-setting plastic parts for all branches of industry. Nor is this technical help limited to knowledge gained within our plant. Our policy of working closely with customers' engineering departments enables us to give designing aid — and from performance data on hand, to make accurate estimates on the service life of proposed plastic applications.

New type plastics and improved molding and fabrication techniques, developed by our engineering staff, increase efficiency and cut costs on widely divergent applications.

We are always glad to answer *any* question regarding the design, production cost or use of molded and fabricated laminated plastic parts.

Write for factual "Data Book"

PANELYTE *the structural plastic*

PANELYTE DIVISION
ST. REGIS PAPER COMPANY
230 PARK AVENUE
NEW YORK 17, N. Y.

Sales Offices: Atlanta, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, Montreal, New Orleans, St. Louis, St. Paul, San Francisco, Seattle, Syracuse, Toronto, Trenton, Vancouver

* MASS PRODUCTION OF SHEETS, RODS, TUBES, MOLDED FORMS, FABRICATED PARTS

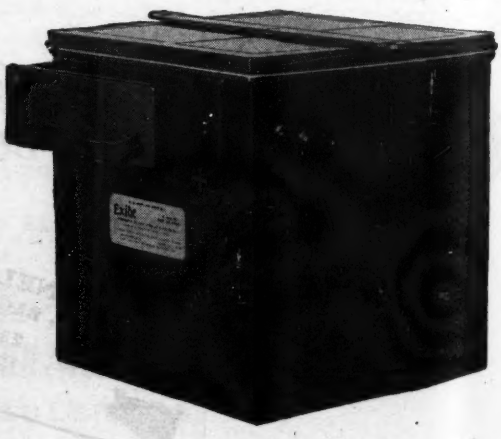
Exide inaugurated Aircraft Battery Service in 1924

The Curtiss "Carrier Pigeon," on the left, and the Fokker 3-engine monoplane, on the right, were rendered Exide Service just before they took off on the Annual Reliability Flight in the fall of 1925.

The world-wide Exide Sales-Service Organization was used as far back as 1924 on some of the most famous flights in aviation history. Exide Service was rendered to the Around-the-World Fliers in 1924, the Pan-American Good-Will Fliers in 1926, and others by the Exide Service Organization all over the world. And currently, Exide service engineers are cooperating on battery problems with the military services.

AFTER THE WAR

Exide aircraft maintenance service will go far beyond the crude stages of 1924. It will be designed and built upon Exide's many years of aviation experience. And this experience, too, will be applied to the designing of the proper battery for post war aircraft.



ARMY E NAVY

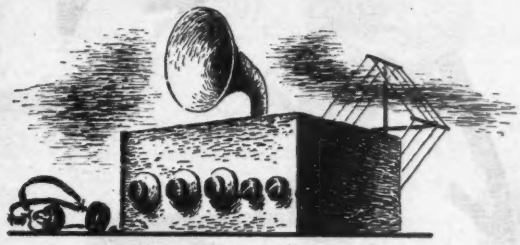
Exide
AIRCRAFT
BATTERIES

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia 32

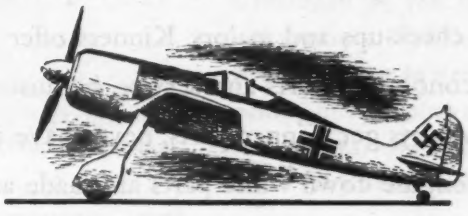
Exide Batteries of Canada, Limited, Toronto

Let SIMMONDS take over part of the Control Room Job

1. Contrary to the trend in other technical fields, the number of instruments and controls tends to increase with the power and size of aircraft. But just as complex conditions in other fields are being handled automatically, the Simmonds-Hobson Automatic Engine Control provides for the known variety of conditions in aircraft engine operation.

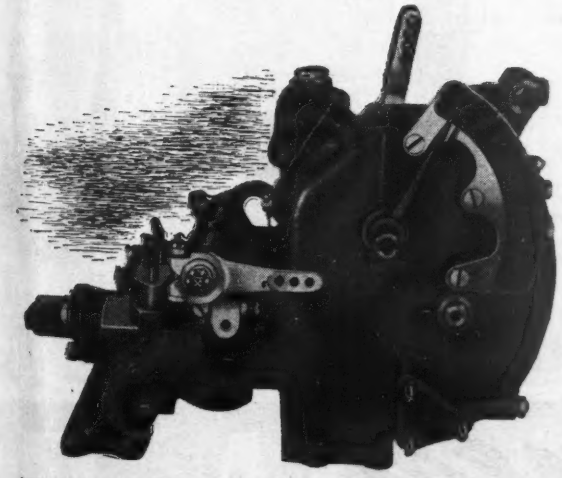


2. No one would consider buying a 5-dial radio today. Modern electronic engineering has demonstrated reception of absolutely equal clarity with only one selection and one volume control.



3. A captured Focke-Wulf 190 discloses a master engine control focusing engine operation in one lever for most flight conditions. The adoption of automatic controls by a resourceful enemy cannot be ignored.

4. Simmonds is now producing a proven control which relieves the pilot of constantly watching manifold pressure and adjusting his mixture. New models will soon extend automatic control to other important engine functions. Simmonds engineers will be glad to discuss the application of these controls to military or commercial aircraft.



SIMMONDS EQUIPMENT FLIES WITH EVERY TYPE OF ALLIED AIRCRAFT

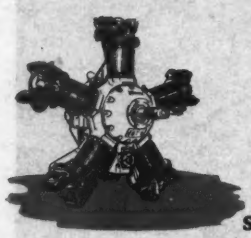
Automatic Engine Controls • Push-Pull Controls • Spark Plugs • Hydraulic Accumulators • Hydraulic Fuses Chronometric Radiosondes • Self-Aligning Rod-End Bearings • Fasteners and Clips of Specialized Design

SIMMONDS AEROCESSORIES INC.

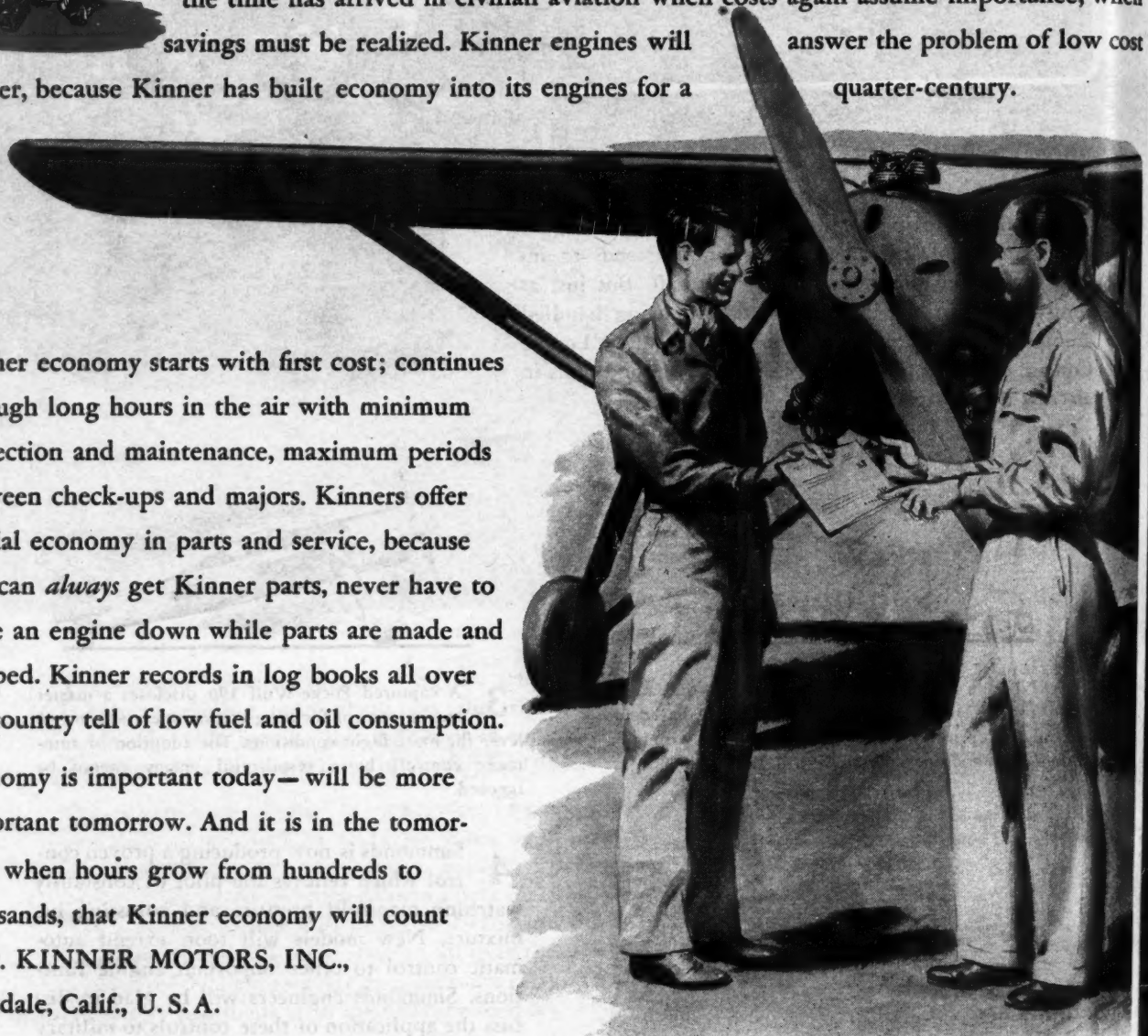
Branch Offices: Dayton • Washington • Hollywood • Montreal

Manufacturing Plants: New York • Vermont • California

It's the Hours between Majors that Count



Engine economy comes first when considering how to keep planes in the air. For, the time has arrived in civilian aviation when costs again assume importance, when savings must be realized. Kinner engines will answer the problem of low cost power, because Kinner has built economy into its engines for a quarter-century.



Kinner economy starts with first cost; continues through long hours in the air with minimum inspection and maintenance, maximum periods between check-ups and majors. Kinners offer special economy in parts and service, because you can *always* get Kinner parts, never have to leave an engine down while parts are made and shipped. Kinner records in log books all over the country tell of low fuel and oil consumption.

Economy is important today—will be more important tomorrow. And it is in the tomorrow, when hours grow from hundreds to thousands, that Kinner economy will count most. KINNER MOTORS, INC., Glendale, Calif., U. S. A.

BUY MORE WAR BONDS

Kinner

1919 — BUILDERS OF DEPENDABLE AIRCRAFT ENGINES FOR A QUARTER CENTURY — 1944

INDUSTRY'S "PROBLEM CHILDREN" Expertly Handled by DoALL Zephyr!

VERSATILE

SPEEDY

COURAGEOUS

Is one word for the Zephyr. When equipped with the proper DoALL Saw Band, it cuts its way through anything spongy, flinty, glass-like, porous, any product that presents cutting difficulties.

With a 36" throat, a work thickness capacity of 20" and a 30" square tilting table, the Zephyr accommodates large castings and die blocks as well as parts of unusual length.

Speedmaster equipped, to give instant variable speeds from 1500 to 10,000 f. p. m., jobs can be turned out in one-half to one-third the former time.

Designed and constructed to well-nigh do the impossible, the Zephyr boldly tackles cutting jobs from which other machines shy away.

***Yes,* you should know more about the DoALL Zephyr. Send for illustrated literature today.**

Developed by the makers of the famous DoALL Contour Machines for faster, cleaner cutting and shaping of today's new materials, as well as some tough old-timers.

- **Magnesium**
- **Aluminum**
- **Non Ferrous Metals**
- **New Plastics**
- **Laminates of all Kinds**
- **For Ripping all kinds of Wood**
- **For Friction Cutting**

DoALL

INDUSTRY'S NEW SET OF TOOLS

CONTINENTAL MACHINES, INC.

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Sales & Service Offices: Baltimore, Boston, Chicago, Cleveland, Denver, Detroit, Erie, Houston, Indianapolis, Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Orlando, Philadelphia, Pittsburgh, Rochester, Rockford, St. Louis, San Francisco, Seattle, Toledo, Tulsa, West Hartford.

WHEN WILL the first blizzard strike? No one knows! That's all the more reason why you should make every effort to insure early readiness—by placing your order for snow removal equipment NOW!

Get the facts today on powerful Walter Snow Fighters . . . proven by tests to be the fastest method of clearing airport runways. There are Walter models to efficiently handle every snow condition, topped by the 250 H.P. Super Snow Fighter. This unit clears a 28 ft. width in one run, at 20-30 m.p.h.—keeps runways clear throughout the worst blizzard—throws snow far to the side to prevent the formation of dangerous snow banks.

This performance comes from the great traction, power and speed produced only by the exclusive Walter Four Point Positive Drive. Full motor-power is delivered to each of the FOUR driving wheels according to its traction at any instant—preventing slipping, stalling and wheel-spinning.

Your first round with snow is fast approaching. Order your Walter Snow Fighters now—and you'll beat any blizzard to the punch this winter!

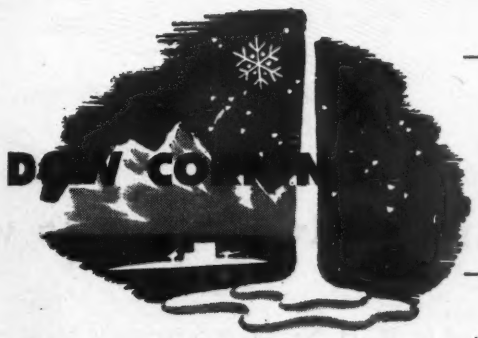
WALTER MOTOR TRUCK COMPANY
1001-19 Irving Ave., Ridgewood 27, Queens, L. I., N. Y.

* Deliveries are now being made on Walter Four Point Positive Drive Tractor Trucks and Snow Fighters for essential civilian needs. The War Production Board has authorized the production of various models, in addition to the military requirements.

SILICONES

Newly Developed Silicone Products Now Available in Commercial Quantities

Dow Corning Fluids possess unique characteristics that warrant their close study by technicians in varied industries—especially those engaged in the current war effort. These water-white permanent liquids are furnished in two series, covering a wide range of viscosities.



FLUIDS

Dow Corning Silicone Products Include:

RESINS—High temperature insulating varnishes for use with heat stable electrical insulating materials.

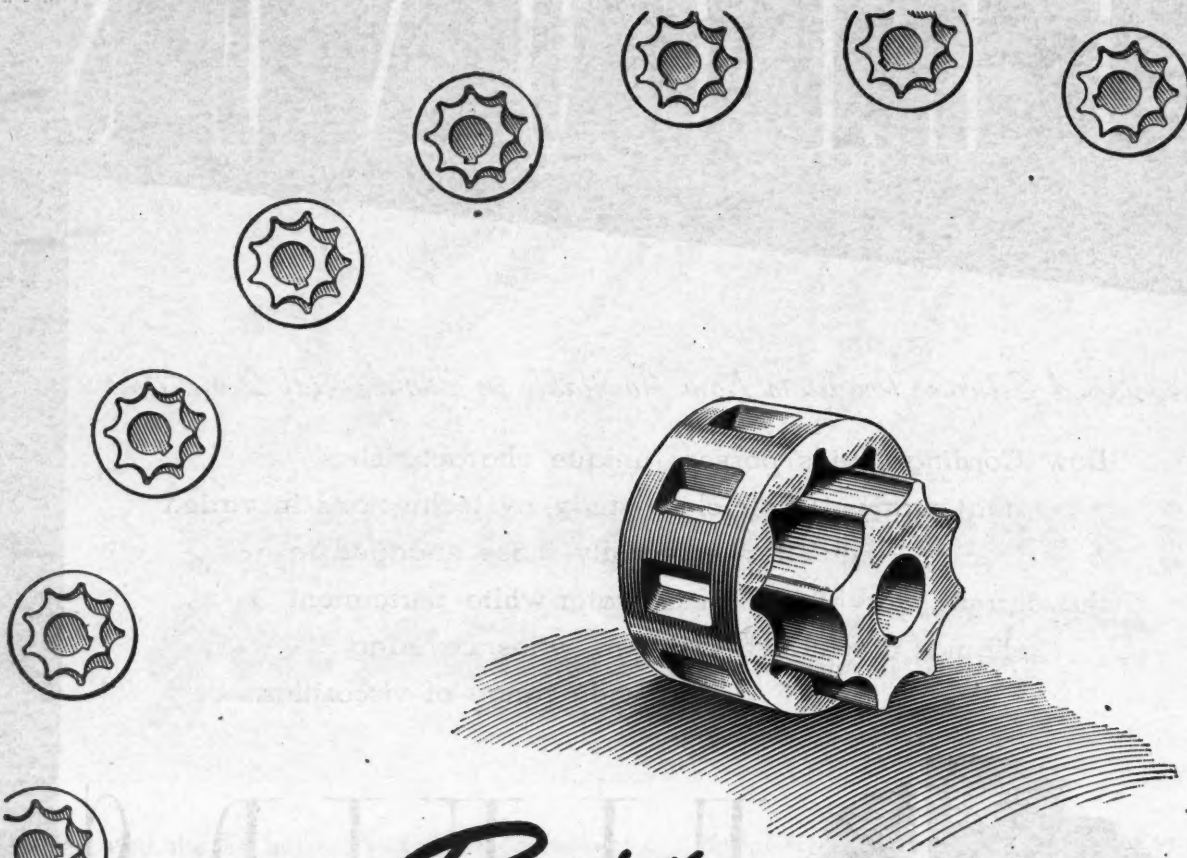
GREASES—For lubrication of valves in high temperature or corrosive chemical services. Plug Cock Grease—for metal valves. Stopcock Grease—for glass and ceramic valves.

Summary of Characteristics

- Remarkably low viscosity change from subzero to high temperatures.
- Exceptionally inert to metals, rubber and plastics.
- Unusually resistant to chemicals and high temperatures.
- Effective water repellent.
- Lubricant for glass, ceramics, plastics.

DOW CORNING CORPORATION
BOX 592, MIDLAND, MICHIGAN

DOW CORNING



Mass-Precision

put this "shelved" idea to work

The principle behind this handful of odd-shaped parts long lay on the "good-ideas-but-can't-be-done" shelf. Engineers who recognized the Gerotor's value in theory discounted its practical possibilities...until it was put up to Nichols.

The stumbling block: Finding ways to produce the inner part to mate with the outer on an interchangeable-parts-and-assembly basis...to extremely close tolerances.

Yet, this principle was too important to remain permanently on the shelf, because it blueprinted a metering pump that could discharge a continuous, *measured* flow of liquid and at the same time draw in a fresh supply. As the inner gerotor revolves continuously in the outer gerotor, the tooth space progressively increases during half a revolution, and simultaneously decreases in its opposite half. The cavity on the increasing side provides the intake, while the cavity on the decreasing side provides the discharge.

Today "the pump that couldn't be made," is not only being produced by W. H. Nichols & Sons but is being assembled without any pre-selection of its parts...something a leading technological institute flatly said was impossible.

In engineering this unit to mass-precision standards, Nichols designed and built special machines and tools to contour grind the hardened inner gerotors and to finish the outer gerotors...applied its thorough knowledge of lapping, as well as accurate hole-sizing and locating. And achieved a compact mechanism that answers today's engineering requirements for light weight, high speed and low price... plus long life.

Your interests may not include Gerotors or pumps of any kind, but the ability of Nichols to bridge the gap between good ideas and their practical mass-production may turn one of your "shelved" post-war blueprints into profitable reality.

Put their future up to "Accurate" Nichols.

W. H. NICHOLS & SONS, WALTHAM 54, MASS.

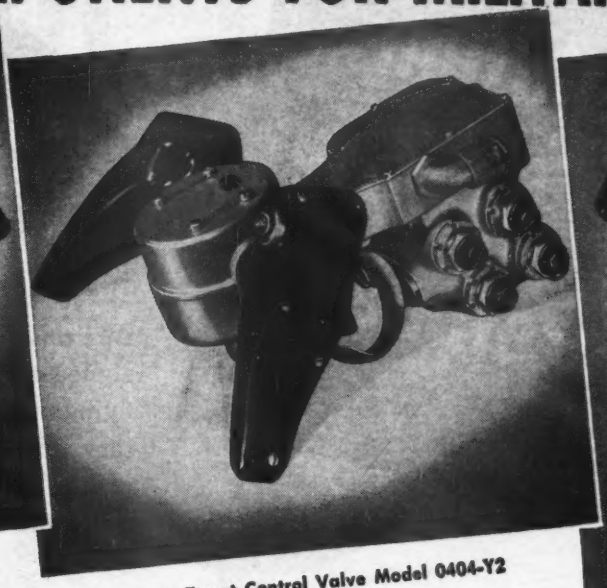
"Accurate" *Nichols*

PRECISION ENGINEERING AND MANUFACTURING FACILITIES FOR MASS PRODUCTION

Clarke-Aero

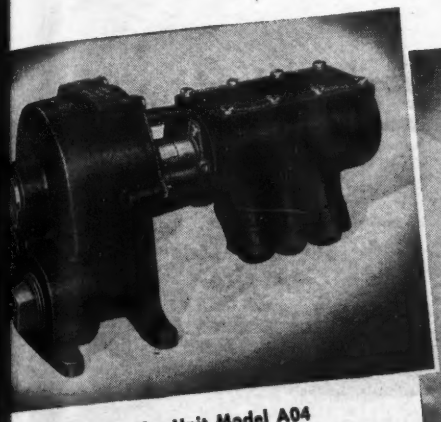
HYDRAULIC COMPONENTS FOR MILITARY AIRCRAFT

Gun Turret Control Valve Model D05-M



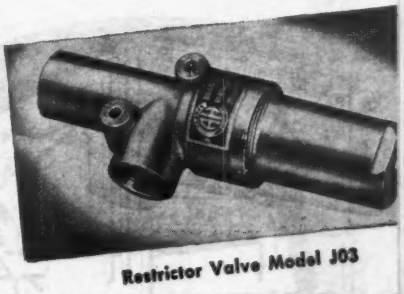
Gun Turret Control Valve Model 0404-Y2

Gun Turret Control Valve Model D05-Y3



Fuel Transfer Unit Model A04

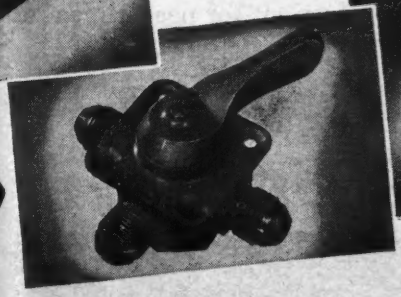
Hydraulic Motor Model C02



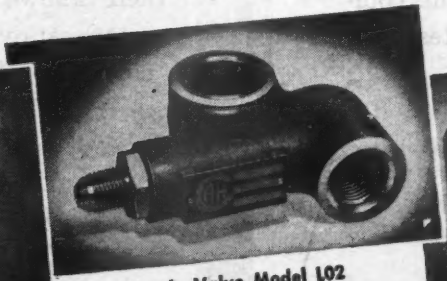
Restrictor Valve Model J03

Gun Elevator Cylinder Model 0601-Y1

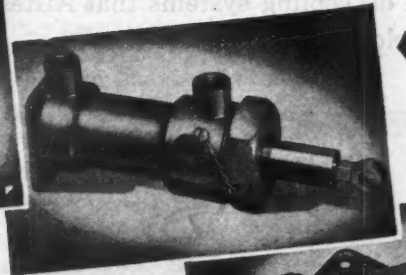
Relief Valve Model E01



Valve, Type, 402-Y2



Shuttle Valve Model L02



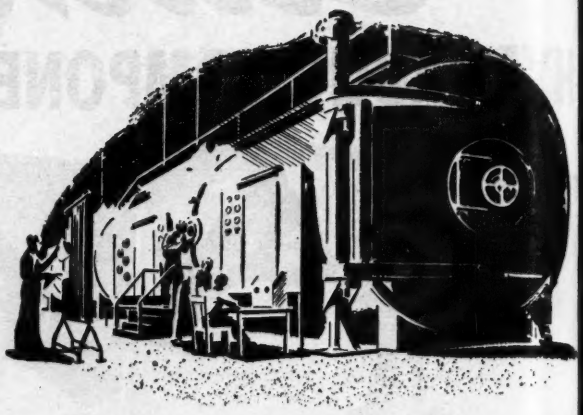
Gill Cylinde Model F01

Rotary Valve Split-Sleeve Ty Model 1401-Y

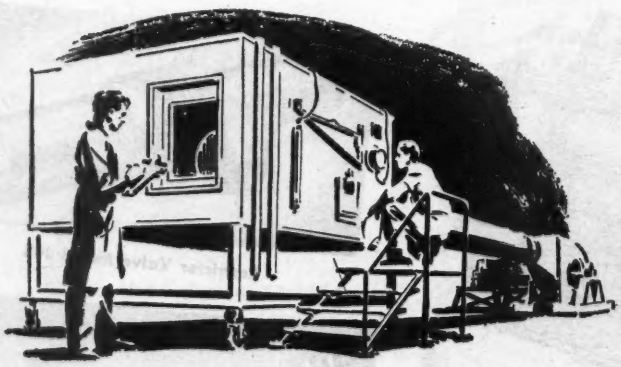
ARMY NAVY E

CLARKE AERO-HYDRAULICS, INC. BOX 591, PASADENA 19, CALIFORN

Will Aviation Progress Slacken in Peacetime?



One answer: the AiResearch "Stratolab." Designed and built for research on high-altitude flying, its facilities are now devoted to military projects. But after the war, this giant pressure chamber will again take on the problems of *commercial* flying.



Another: the AiResearch Wind Tunnel. This, too, will return to peacetime projects, helping solve such problems as the adaptation for tomorrow's finer airliners of the new intercooling and oil cooling systems that AiResearch has developed for planes of war.

More: AiResearch specialists who perfected automatic exit flap controls... lightweight intercoolers... anti-congealing oil coolers. From their "know-how" will come new heat transfer and pressure control systems, and AiResearch "comfort-protection" for peacetime aircraft.

ARMY E NAVY

"Where Controlled Air Does The Job"
Supercharger Aftercooling Systems • Engine Air Intercooling Systems • Automatic Exit Flap Control Systems • Temperature Control Systems • Engine Oil Cooling Systems

AiResearch
DIVISION OF
THE GARRETT CORPORATION

STOP "Leap-Frog" Corrosion

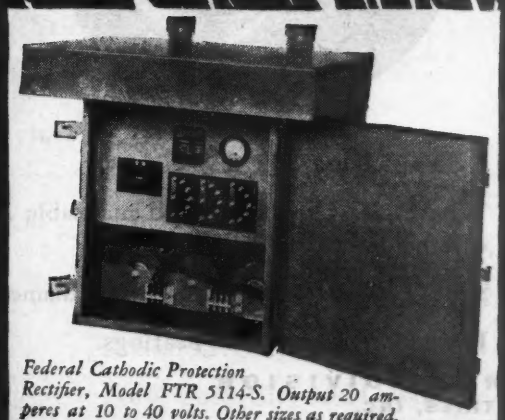
"Leap-Frog" Corrosion damages underground pipes and cables.

Pipes or other metal structures are in places electro-positive in relation to the soil and due to natural galvanic action corrosion results. Metal is taken away from one section of pipe and deposited somewhere else along the exposed pipe.

By using Federal Cathodic Protection Rectifiers, "Leap-Frog" corrosion is foiled. On constant guard is a direct current charge which cancels the harmful electrolytic corrosive action on oil, gas and water pipelines and underground cables.

These Federal units have no moving parts, so they last indefinitely — with the absolute minimum of attention. In desert heat or torrid dampness they keep on the job day and night.

Proper engineering for the corrosion problem at hand calls for the specialized consulting engineering service which is yours — when you look to Federal. Write today for full details.



Federal Cathodic Protection Rectifier, Model FTR 5114-S. Output 20 amperes at 10 to 40 volts. Other sizes as required.

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1, N. J.

THE BRUISER

4000 lbs. PER CASTER

Here is a little giant with the strength to take the heavy parts used in the assembly of large bombers. Free-swiveling, light rolling —four of these Bruisers will handle up to 16000 lbs. with ease.

Check this New FORGEWELD

Against Your Requirements

- ☐ UNBREAKABLE—Top plate forged of SAE-1045 carbon steel with integral king bolt. Yoke base forged of SAE-1045 steel with structural steel legs.
- ☐ Swivel—double ball race in machined raceways with Brinell hardness of 230.
- ☐ Axle and King Bolt 1¼" diameter.
- ☐ Wheels—cast steel, certified malleable iron or moulded plastic type.
- ☐ Size of "wheels"—Standard, 8" to 12" diameter.
- ☐ Hyatt or Timken roller bearings.

SERVICE CASTER & TRUCK DIVISION
OF DOMESTIC INDUSTRIES, INC.
510 N. Brownswood Avenue, Albion, Michigan

428 Somerville Ave., Somerville (Boston) Mass.

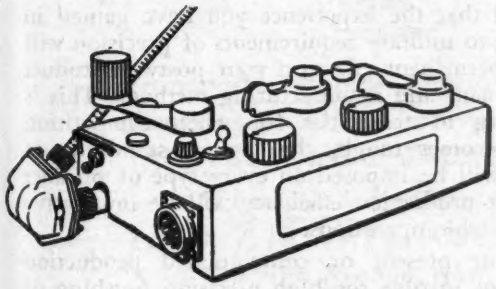
Toronto, Canada: United Steel Corporation, Ltd., SCAT Co. Division

· DI · SERVICE

ARMY E NAVY

Altair* VARIABLE ANGLE DRIVE

These new angle drives have four outstanding characteristics for use in connection with remote radio tuning or rotation of any item.



1. The drive can be rotated through 360°.
2. Fits standard type male and female shaft connections.
3. The unit is serviced by removal of one bolt – and without disturbing the shaft connections.
4. Serves as the anchor point for tach shaft installation.

Altair* Variable angle drives are available to fit both MC 164 and MC 215 tach shafts. Complete information will be supplied on request. Pacific Division, Bendix Aviation Corporation, North Hollywood, California. Sales Engineering offices in New York City and Dayton.

The new trade name of products manufactured by Pacific Division, Bendix Aviation Corporation.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

DESIGNERS AND MANUFACTURERS OF RADIO AND HYDRAULIC EQUIPMENT—OUR PART OF THE INVISIBLE CREW

© 1944 Pacific Division, Bendix Aviation Corp.

IT'S all right to talk about new plastic refrigerators—glass ranges—"miracle" homes with solar heat—visionary automobiles made of magical new materials by revolutionary manufacturing methods—but, if buyers have to wait months, maybe years for such products, the manufacturers are not going to hear that merry tinkle in the till for some time to come.

The immediate demand will be for products that have acceptance—in all probability the old standbys of your pre-war product line with new improvements to be sure—products you know will give customers satisfaction—products that will give you low selling cost, low service cost with quick turnover and profits.

So we submit that wise postwar planning should prompt you to go through two stages—

Get into production on essentially those products you've sold or made before—improve, but be careful of radical changes.

Bring along those revolutionary new developments as quickly as they can be "proved."

It is wise to remember that products that are "coming" ring no bell including the one on the cash register, until they arrive. The products you made and sold in the past gave mighty good customer satisfaction and performance. To help meet the immediate postwar demand, what would be more sensible than to offer your customers and prospects good, proven products—*fast!*

We hope you'll agree with this outline of our thinking. We call it *"Postwar planning with both feet on the ground."*

Since industrial progress has always been evolutionary . . . *never revolutionary*, it is only to be expected that the experience you have gained in working to military requirements of precision will have a permanent effect on your postwar product development and manufacturing methods. This is something to remember for when competition really becomes tough, the highest standards of quality will be imposed on every type of product—utmost production efficiency will be imperative for profitable operations.

If your present or contemplated production operations involve the high precision finishing of metals, wood, plastic or new alloys—let McAleer make those operations profitable. During this war we have been privileged to help many manufacturers solve the varied and complex problems involved in the hypercritical finishing of many kinds of high precision war equipment. These same companies, we feel, will turn naturally to McAleer for the answer to their postwar product finishing needs. We want you to feel free to do the same.

McAleer
MANUFACTURING CO.

Manufacturers of Quality-Controlled Finishing Materials, Military Aircraft Sub-assemblies and Pyrotechnics . . .

ROCHESTER, MICHIGAN

"BG spark plugs have proven their reliability in TACA'S planes during ten years of flying in Latin America."

TACA AIRWAYS SYSTEM

Transportes Aereos Centro Americanos
Aerovias Brasil • Aerovias Argentinas
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Represented in the United States by

TACA AIRWAYS AGENCY, INC.
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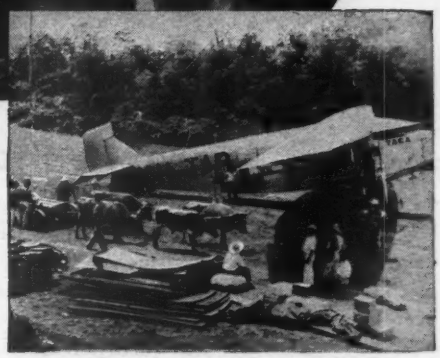


▲ 22,126,000 pounds of cargo in '43
▼ 55,143 pounds of quartz crystal from Brasil in '43

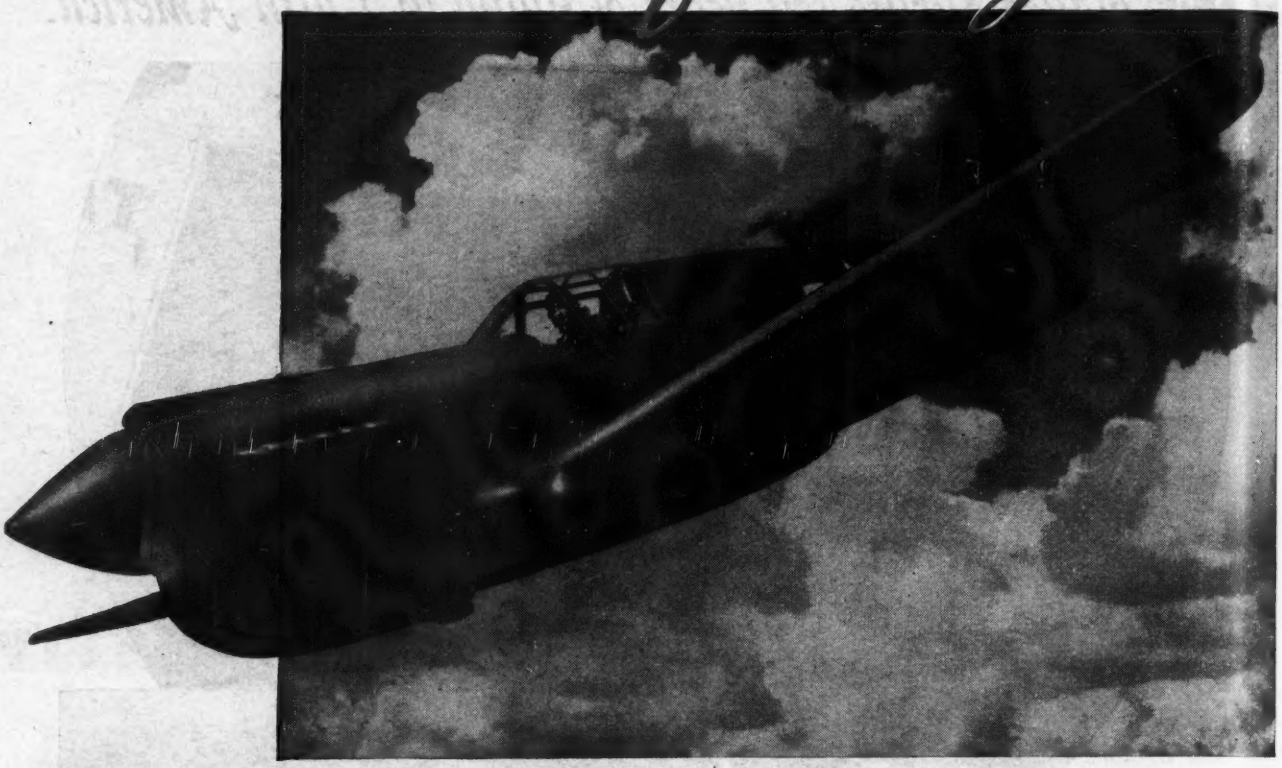
ARMY E NAVY

BG

THE BG CORPORATION
136 WEST 52nd STREET, NEW YORK 19, N. Y.

Contractors to the United States Army, Navy and Coast Guard and Aircraft Engine Builders

THE PLANE WITH THE *habit of coming back*



proves the importance of dependable controls

In the grim business of combat flying, quickness and sureness of controls—hair-trigger response to the pilot's touch on switch and lever—often determine who will return from a mission.

The Curtiss P-40 Warhawk, famous veteran of this war's battle skies, uses American Tiger Brand Control Cables to provide the sensitive, unfailing response so necessary for survival.

Because of the flying safety they assure, these high-quality cables are standard equipment on America's most famous combat and commercial planes.

With ample strength to handle maximum loads, they combine lightness, minimum stretch, excellent flexibility and superior resistance to fatigue, wear and abrasion.

The fact that they are of Excellay Preformed construction is further assurance of their flawless performance in service.

AMERICAN *Tiger Brand* CONTROL CABLES

USS

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York

COLUMBIA STEEL COMPANY
San Francisco

United States Steel Export Company, New York

★ *Buy and hold as many War Bonds as you can afford* ★

UNITED STATES STEEL

pre-fabricated housing into the plants of plane makers who will have no immediate use for their facilities when war orders are terminated. These houses, it is reported, would be supplied to some of the liberated areas in Europe.

Such a program might prove a desirable stop gap for some aircraft concerns during the interim when surplus planes are being disposed of and peacetime aircraft products are being readied for the market.

In the meantime there is one favorable phase of the industry's early reconversion years that has had little notice. Large tax refunds will be flowing into company treasuries at a time when they will be most needed. In the case of Curtiss-Wright Corp., for example, postwar tax refunds in 1942 amounted to $7,993,000 and totaled $9,088,000 in 1943. That means that $17,081,000 will accrue to Curtiss-Wright from the government in refunded tax money after the war. And this refund will be still larger as a result of 1944 and 1945 war contract operations.

Tax refunds will continue to accumulate for all aircraft companies as long as war volume keeps them in the upper tax brackets.

Fan Cooling

(*Continued from page* 159)

ing angles of relative velocity, B_1 and B_2, calculated, and then joining these by a curve, those fans with very high pressure coefficients having rising characteristics, while low pressure coefficient fans have declining characteristics with increasing volume.

On receipt of design information concerning the fan built by Curtiss-Wright at St. Louis, it was decided to determine how far the curvature of this so-called "stream filament" blading can be carried without breakaway for high total-pressure boost for various conditions and, equally important, what are the limitations of this approach in terms of static-pressure conversion achieved within a reasonable axial travel? These objectives involve research on control of tangential acceleration of the air, and expansion between the blades, as influenced by blade curvature, blade shape, and degree of "Schichting," both for rotor and stator vanes, and entering blade angle for fans of low and high capacity.

Unlike our earlier fan designs, we believed that sheet metal vanes of constant thickness, making for rugged design, should be equally as effective as streamlined shapes, the areas of path between blades being taken care of by correct curvatures. These ideas were taken directly from similar design research on supercharger entrance and diffuser vanes conducted by ourselves, a number of other companies, and the NACA over several years. All models for laboratory testing have been designed on this basis.

Pending laboratory tests, the rotor of the last geared-engine nose fan described above (Fig. 9) was redesigned to incorporate sheet-metal blades. Due to

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the relatively high fan speed (engine crankshaft speed) and the goal of only 10 in. static-pressure boost at sea level, this is a low pressure coefficient design. However, higher boost blades have subsequently been applied to propeller-speed fans on airplanes and are forthcoming for geared fans as required.

Recently a propeller-speed fan and after-vane has been designed to improve cruising performance of a large flying boat with twin-row radial engines. With the ship flying at far greater load than its original design value, severe induced cooling penalties, such as those explained earlier, were being encountered, resulting in unsatisfactory cruising performance.

It was planned that the fan should give 4 in. additional boost at 2,100 engine rpm. at 4,000 ft. on a hot day, with propeller turning at .4375 of engine speed. This is considerably more difficult than those performances designers declined to try for in the early days.

Large Spinner Used

The first fan blades fell short of giving the required boost, because the helical component of approach due to the propeller was not allowed for sufficiently. The first fan was also tested with and without a large spinner (32 in. o.d.), and since no difference in performance could be detected, the production version was built without it.

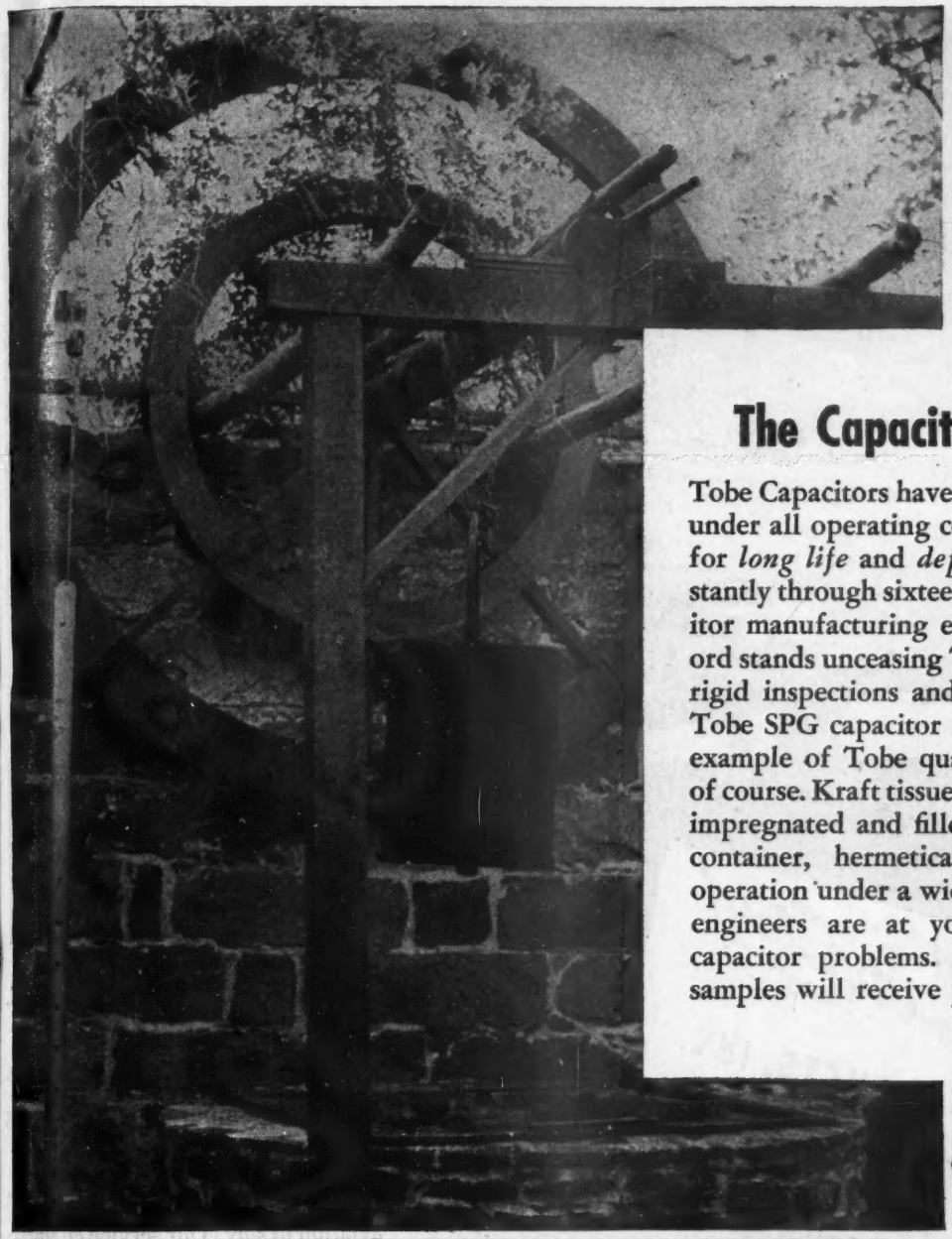
Cooling and airspeed in cruising are both distinctly improved with the 4+ in. boost obtained. In addition, taxiing, takeoff, and rated-power climb are now made with flaps in the streamlined position. Ten inches water baffle pressure drop is achieved at takeoff, and about 13 in. water baffle pressure drop is obtained in rated-power climb. Of the latter, about half accrues from the fan. Pressures around the engine are quite uniform.

Figs. 11, 12, and 13 (herewith) offer fan details. Fig. 14 is a sectional view of the installation. Note the small degree of "Schichting," all at the root end of the blade. Also note the very high rotor blade entrance angles necessary and the trailing angle of the blade at the root, which curves around to discharge the air slightly in the direction of rotation. The diffuser is built along the lines of supercharger diffusers; that is, a gradual increase of area at first, as influenced importantly by the sine of the vane angle, gradually increasing along the path. Fig. 15 and 16 show fan and installation itself. This fan is currently in production.

Low Altitude Fan

Just prior to the above project, a propeller-speed fan for a single-row radial was installed in a test ship. Fig. 17 is a photo of the installation, and Fig. 18 offers details of the rotor.

The fan, designed before the one for the flying boat, was built to an easier assignment in spite of being for a higher boost. The propeller runs at .667 of engine speed, instead of .437, and the volume of cooling air flow is reduced 35 percent. It should be pointed out, how-



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STANDARD CAPACITANCE TOLERANCE	20%**
TEST VOLTAGE	Twice D. C. rating
GROUND TEST	2,500 Volts D. C.
OPERATING TEMPERATURE	-55° F to 185° F
SHUNT RESISTANCE	
	.05 to 0.1 mfd. 20,000 megohms
	.25 to 0.5 mfd. 12,000 megohms
	1.0 mfd. 10,000 megohms
	2.0 mfd. 5,000 megohms
POWER FACTOR	1,000 cycles—.002 to .005
CONTAINER SIZE	
	Width ⅜", length 1 5/16", height 2¼"
MOUNTING HOLE CENTERS	1½"

MIDGET SPG-CAPACITORS

TYPE	SPGM*
RATINGS	.05, .1 and 2 x .05 600 V. D. C. .05 and .1 1,000 V. D. C.
STANDARD CAPACITANCE TOLERANCE	20%**
GROUND TEST	2,500 V. D. C.
OPERATING TEMPERATURES	-55° F to 185° F
SHUNT RESISTANCE	20,000 megohms
POWER FACTOR	At 1,000 cycles—.0075
CONTAINER SIZE	
	Width ⅜", length 1 5/16", height 1 11/64"
MOUNTING HOLE CENTERS	1½"

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over, that this is not truly a high-altitude fan. It was designed for low and intermediate altitude work to give 10 in. of boost at rated power, sea level, and about 5 in. at 20,000 ft. This fan should be of particular interest in transport operation.

A higher altitude propeller-speed fan for an engine of this size and gear ratio is perfectly feasible—say, one which would give 4 or 5 in. of static boost (not total) at 30,000 ft.—but it must then be designed for a very much increased air quantity because (a) volume increases with altitude inversely as the square root of the density for a given baffle pressure drop, and (b) intercooler air must be added to the fan capacity. This would call for higher, steeper, and more curved blades, and it would be a more limiting design case, like the fan described above for application to a flying boat.

Tests on this fan are still proceeding; an identical fan structure without blades has been provided for flight comparison to determine the actual gain from the fan boost. It is also intended to compare performance of the entire fan installation with that of a similar airplane having the original installation but using this later engine. Fig. 19 gives pressures thus far achieved in flight at various gill openings. Examination of these will indicate that the fan boost is about as expected from the formulas.

Structurally and mechanically, the gilled exit opening—as opposed to the hinged flap type—is working out well with this fan installation. It appears that the full-open gilled exit does not impose any additional penalties on airplane performance, while at the same time it allows full use of fan performance to achieve additional engine cooling. Here, again, additional flight testing must be accomplished, and it is planned to determine the optimum rewards and deficiencies with this type of installation though considerable time may be required.

We believe that J. J. Jerger, of the Curtiss-Wright Airplane Div., St. Louis, was the first to appreciate the importance of the Schicht and Wattendorf principles and to initiate their application. Important ideas with reference to structural design of several of the fans described were contributed by Messrs. Roland and Allan Chilton of the Wright Aeronautical Corp. The Glenn L. Martin Co. provided the test ship and crew and fabricated aftervanes for the flying boat fan project; Curtiss Propeller Div. assumed over-all responsibility for the project; and Benson Manufacturing Co. contributed important structural features and fabricated rotors for this and other projects during the year. The flying boat project was made possible through the active support of the U. S. Navy, with special thanks due Capt. S. B. Spangler and Lt. C. W. Ray.

W. M. S. Richards, assistant project engineer on cooling research; and B. J. Mezger, on fan development, both of the writer's staff at Wright Aeronautical have provided invaluable help in the analysis and compilation of the data used in this paper.

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It Takes a Flight Engineer

(*Continued from page* 185)

facturers have super-transport designs already in the mockup stage, and they are only awaiting the war's end to put them into large-scale production. Inevitable competition for postwar markets will require maximum efficiency in aircraft production and, no less important, maximum utilization by the operator.

This optimum utilization must be accomplished by refining the operating and maintenance techniques to emphasize human control as differentiated from automatic control. It will be noted that this is opposite to the philosophy prevalent in the design of present-day planes for military use. The tendency there has been to eliminate the human element as much as possible, to permit crewmen to devote as much of their skill as possible to the business of fighting. The emphasis on the operation of the plane as a means of transport is secondary to its use as a weapon of war.

While automatic control of carburetors, superchargers, and other operating components relieves the pilot of some manipulation and adjustment, it is done at the expense of operating economies which can be scarcely afforded in a business of marginal profits and keen competition. For this reason, the airliners of the future will be designed to utilize a crew of highly skilled specialists, in order to reap the operating economies inherent in an efficient combination of man and machine.

The crew will be organized around two key individuals, much in the manner of surface-vessel crew organization today. First, a captain, whose function will be to determine the best possible means of accomplishing the flight, and, accordingly, give the necessary commands to carry out the flight. Second, the flight engineer, who will be responsible for the mechanical functioning of the aircraft and its efficient operation. Under the direct supervision of the captain will be the avigation, communication, and pilot officers; and the flight engineer will directly supervise an appropriate number of flight mechanic officers (also subject to captain's command).

What Flight Engineer Does

Paralleling closely the functions of the chief engineer and his subordinates aboard surface vessels, the flight engineer and his crew of flight mechanics are concerned primarily with the mechanical functioning of the plane in flight, from standpoints of maintenance and operation. From the former viewpoint, the flight engineer's foremost problem is trouble shooting. He must diagnose the cause of any mechanical abnormality, decide the importance (relative to continued operation) of the trouble, and draft the plan of action to be followed.

Usually, it will be the flight engineer's decision, which the captain will follow. Thus, he must have not only an intimate knowledge of the principles of operation of all the mechanical, electrical, and hydraulic components, but he must have a definite facility for analysis of symptoms

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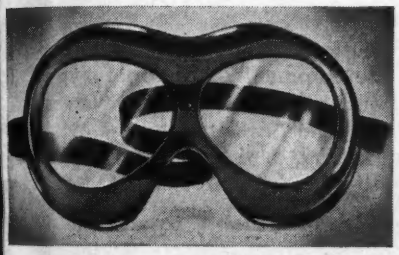

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when troubles occur, as well as sufficient experience to recognize and track down all factors involved.

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Variations in symptoms as the engine controls are manipulated will often be a reliable index of the source and extent of any powerplant trouble. For example, an engine that is rough only at high speeds leads one to immediately suspect weak or broken valve springs, while an engine which is rough at low speeds and low head temperatures, but which smooths out at higher rpm's probably has sludge in the valve guides.

Closely allied to trouble shooting, the completion of any feasible repairs or adjustments in flight—sometimes reaching an importance of serious proportions—is another concern of the flight engineer. The following incident is in point: A piston failure was experienced in No. 4 engine about four hours out of the main base. The engine was shut down, prop feathered, and the plane was proceeding back on three engines when manifold pressure of engine No. 1 fell off to approximately 10 in. Since the plane would not maintain altitude at this power, No. 4 was restarted and warmed-up. However, it was impossible to take enough power out of No. 4 to do more than merely reduce the rate of descent.

Fortunately, the flight engineer found the trouble in No. 1 to be due to a broken throttle control rod forward of the firewall. He replaced the broken rod with a spare and returned No. 1 to service while the crew secured the ship for an open sea landing. Here was a spectacular example of plane being saved from certain loss simply because of the provision for engine accessibility in flight combined with the work of an alert and experienced flight engineer.

No less important from a maintenance standpoint is the supervision and inspection of ground crew service and repairs—another duty of the flight engineer. In this respect, he is able to disseminate valuable information on the latest developments in maintenance procedures to personnel at outlying bases where involved communication with the main base is otherwise difficult. Lines of communication, when thrown over thousands of miles of territory, can become tenuous at times, causing the written word to lag the oral by days or even weeks, a time lag which might have serious results.

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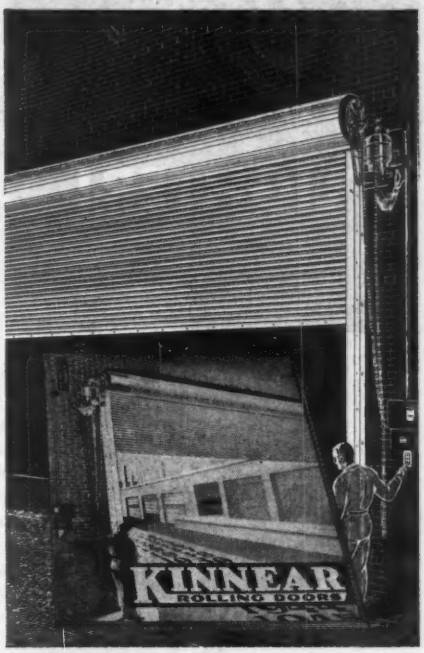

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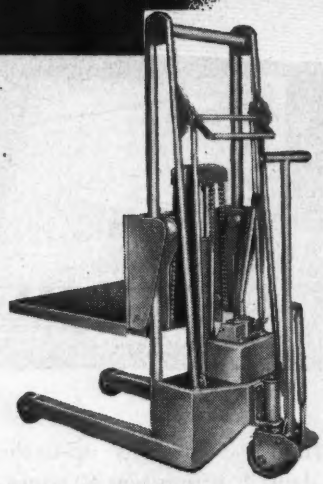

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Every pound of fuel loaded means a corresponding decrease in allowable pay load. Consequently, the fuel load must be held to a minimum, consistent with safety. The amount of fuel carried will include allowances for current meteorological conditions, and reserves for forecasting inaccuracies. Any increase in fuel consumption will be due, ordinarily, to unpredictable circumstances, such as an engine trouble or inaccurate cruising control. The latter may be reduced to a minimum by precise powerplant adjustment in conformance with variations in gross weight, altitude, air density, wind component and other factors.

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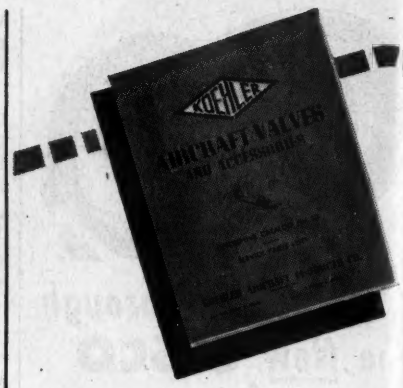
Reserves to provide for "busts" in the flight time analysis will be reduced as weather forecasting becomes more reliable, while efficient design of the airplane, engine, and propeller combination will reduce the effect of partial power failure upon the over-all operating efficiency. It will be seen, then, that the flight engineer can effect valuable reductions in fuel load by developing efficient cruising-control techniques, by assisting in the design of more efficient aircraft and powerplants and by operating the aircraft accurately and precisely during flight.

In flight, the engineer will ordinarily confer with the captain to determine the best possible means of carrying out the trip, and he will then make the necessary powerplant adjustments. It will be the engineer's responsibility to keep a running log of the mechanical operation and functioning of the plane, as well as an appropriate record of the fuel consumption and remaining endurance at any time. Besides providing a permanent record of operation, these logs are of inestimable value in tracing the development of any mechanical difficulties which may occur in flight. For example, the trend of a slow drop in oil pressure accompanied by a rise in oil temperature may indicate



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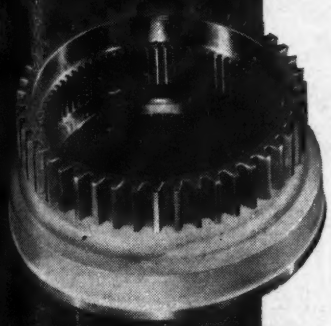

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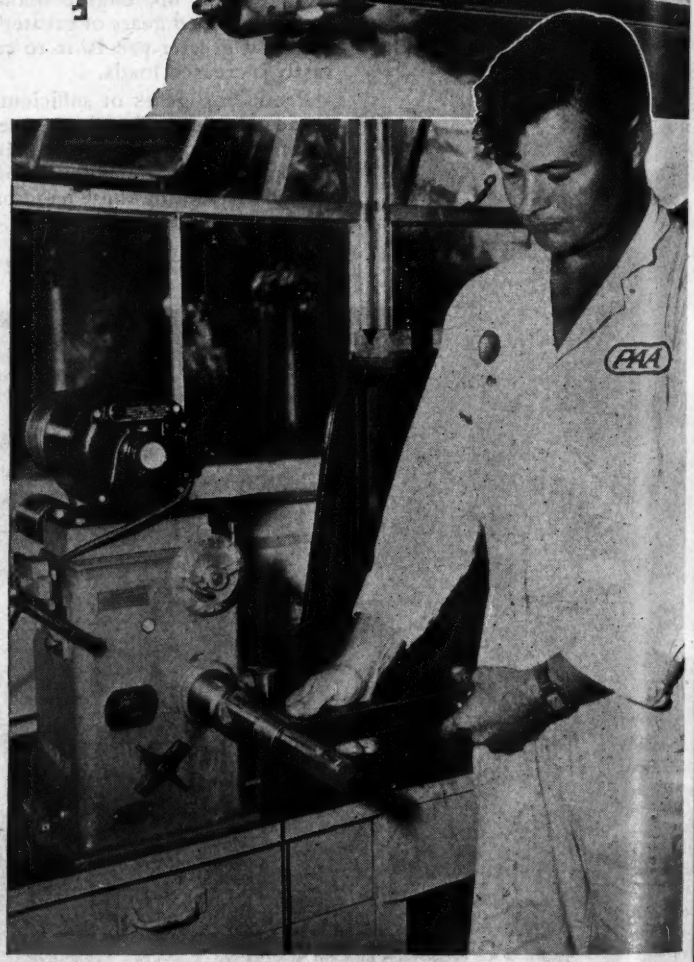

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In conjunction with the immediate problem of operating the plane from point to point, the flight engineer has certain long-range concerns. The problem of developing efficient cruising-control techniques has already been mentioned. He has a wealth of first-hand experience with the operating problems actually encountered, and he is able to temper purely ideal theoretical data so that it fits the particular situation being considered.

For example, most flight-test data, whether determined by the manufacturer or operator, is usually expressed in terms of standard air and under ideal conditions. The flight engineer is in a position to make appropriate allowances for climatic conditions, maintenance facilities, load requirements, and other purely local conditions existing over the route flown, and thus assists in the development of techniques to meet the particular problem encountered.

In the design of aircraft and equipment, the flight engineer may supply specifications, offer suggestions, and often undertake original, independent design himself. His experience has given him an insight into the problems encountered in the particular type of operation with which he is concerned. This first-hand knowledge of the problems involved is one of the prerequisites of good design. His is an intimate knowledge, not only of the performance required but also of the advantages and shortcomings of similar equipment.

In short, the operator will often be confronted with a choice between two or more items. In this dilemma he is able to consult the flight engineer, who can supply him with a sound background of performance characteristics, based upon experience with the operation of the units in question or of similar units, upon which a judicious choice can be predicated.

Ordinarily, when a new transport plane is in the preliminary design and production stages, the manufacturer will call upon the future operators to assist in preparing specifications. The operator, on the other hand, will want to keep his finger in the pie, to assure quality of material and workmanship, and to gather information on construction, repair, maintenance, and operation which will be of value when the plane is in operation. This factory inspection function can most effectively be handled by the flight engineer. Since he, personally, will some day be flying in the plane, he will be meticulous in his inspection of the design attributes and production processes, also the evaluation of them with respect to the proposed operation. He will be able to gather whatever information may be necessary to operate the plane with a maximum of efficiency.

The familiarity which he will acquire with the ship while it is under construction, will eliminate much of the time lost in crew familiarization when the ship is delivered. Since he is bound closely to the airline's ground crews, and is familiar with their methods of maintenance, he is eminently qualified to in-

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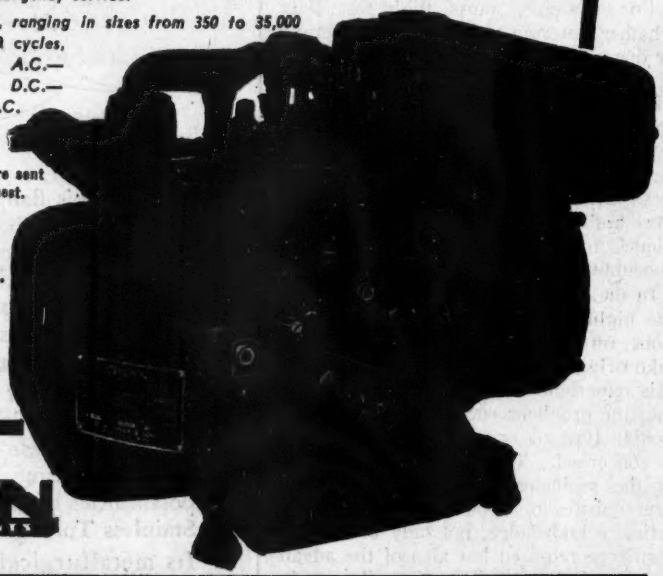

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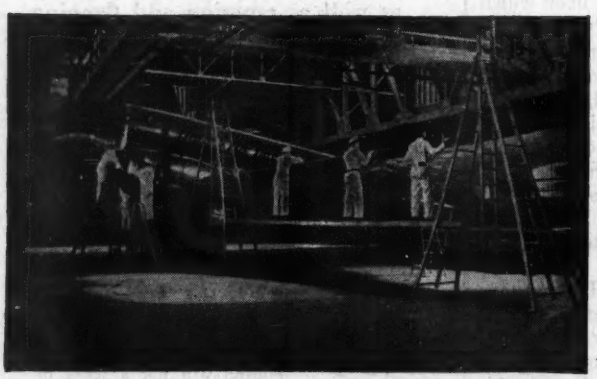

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struct mechanics in new servicing and maintenance procedures, also to adapt these new methods to his company's way of doing things.

Development of improved standards of maintenance is another major concern of the flight engineer. Here again he has first-hand knowledge of the problems confronting the maintenance organization, as well as a healthy self-interest in the highest possible standards. Specifically, he can evaluate the results of given procedures with a view to refining and improving them. Since his practical background has necessarily included considerable experience as a member of the maintenance organization, he will be intimately acquainted with the procedures as they exist, and he will thus be in an excellent position to study and develop possible advancements in maintenance methods and procedures.

It is realized that, human nature being what it is, the maintenance personnel are apt to differ with the operations personnel in their interpretation of a basic problem. This is typical of any organization with two such interdependent departments. Operations finds it hard to evaluate the difficulties which confront the maintenance department, and vice versa. This difference in interpretation between the two organizations has been one of the problems involved in air transport. The flight engineer can do much here to enhance mutual understanding. He is primarily concerned with an airline's basic problem: To get the ship economically from here to there, with the greatest load, as often and as fast as possible, consistent with perfect safety; and he is also aware of the functions and problems peculiar to both operation and maintenance departments. Therefore, he can meet either department on its home ground and explain the actions of the other in light of the basic over-all problem, thus promoting maximum cooperation within the organization.

Another function of the flight engineer arises from his frequent presence at all of the line bases. Thus, he can supply personnel with news of both personal and business nature. The importance of this relationship, when properly maintained, cannot be overestimated. These human touches are the very life-blood of an air transport organization, because air transport depends upon skill and loyalty far more than is ordinarily realized.

Flight Engineer Qualifications

It is apparent that here is a job which is a product of our generation and which requires an individual capable of fulfilling stringent requirements. Now, what qualifications should a man have to become a flight engineer?

To discharge his duties, it is obvious that he must have a thorough grounding in the principles of engineering as applied to aircraft design and operation. Men for this job have, in the past, been selected from two sources—college graduates in engineering, and mechanics with several years' experience in airline maintenance and operation. True, friction may arise, when college men and non-college men are thrown together to do

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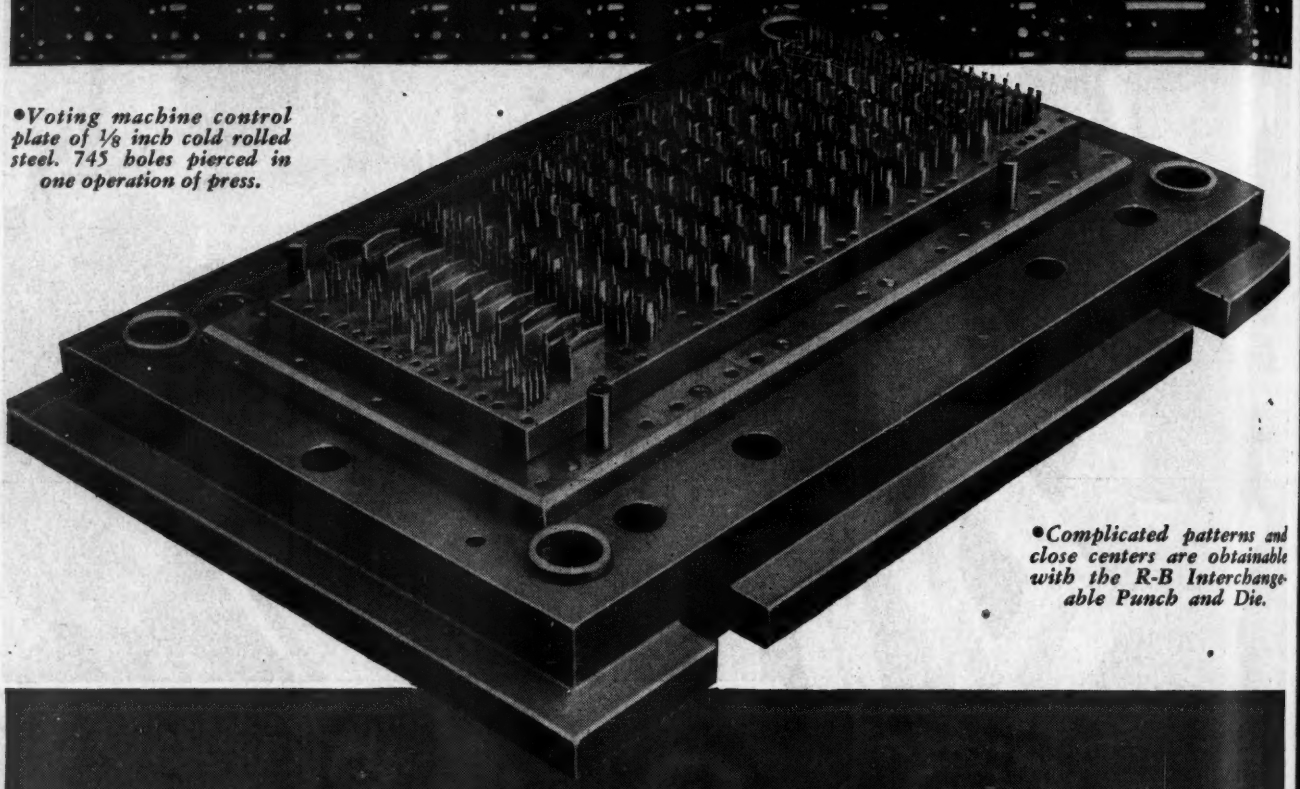

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the same job. But the fault lies with neither side, and if there is tolerance, consideration, and understanding on both sides, we have found that mutual respect arises. Each background has something to offer the other; the two complement and are vital to each other.

The practical man, for example, is more qualified immediately to assume duties of flight mechanic, whereas the man fresh from college requires considerable practical experience before he is so qualified. However the purely practical man with no theoretical background is obviously incapable of the job of flight engineer without additional training. Hence, there is no escaping the conclusion that, regardless of source of background and means of acquiring it, certain requirements are necessary. It matters little *how* a man fulfills them, the important thing is that he *does*. This should be borne in mind while evaluating the standards set forth below.

The foregoing discussion of duties and responsibilities implies that the prime requisite of the flight engineer is the ability to apply the principles of logical analysis to the specific problems of operation and maintenance. This ability will be recognized as the principal trait inherent in the makeup of any competent professional engineer, whether his specialty be civil, mechanical, or electrical engineering. It is also a trait markedly present in a good, sound mechanic. It is a product of the combination of background and natural inclinations. In a sense, it is a quality which is a part of the basic psychologic makeup of man but which is useless if not awakened and developed by that combination of education and experience which we call background.

One method of acquiring the educational part of this background is, of course, through a regular college of mechanical or aeronautical engineering, for nowhere but in a university is a man trained as intensively in the application of logical analysis to the solution of problems in general. Lack of a college background, though not an insurmountable obstacle, is a hindrance to a potential flight engineer, but it can be overcome with sufficient home study or the equivalent, coupled with determination.

On the other hand, the mere fact that a man has an engineering education is no guarantee that he will make a good flight engineer. That will be determined by whatever natural talents he possesses, plus the degree to which his education has developed those talents. However, all other factors being equal, engineering training will enable the flight engineer to develop his skills and abilities to the maximum level commensurate with his individual talents.

Another and no less important part of the man's background is the on-the-job experience with aircraft equipment, operation, and maintenance. It is obvious from a review of his duties, that the flight engineer must be thoroughly familiar with the operating principles and techniques and the maintenance procedures for all components of the plane in which he flies. This involves extensive experience with aircraft powerplants, as well as

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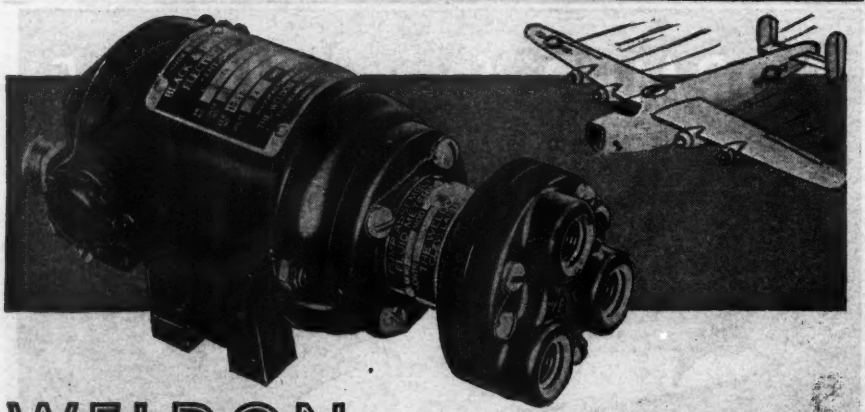

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with electrical, hydraulic, fuel, oil, and control systems in general, also structures and basic aerodynamics. In short, besides having an extensive theoretical knowledge, he must be an experienced aircraft and engine mechanic.

In general, a college man must have approximately one to two years' ground experience in maintenance and related problems, in addition to his formal education, before he is in a position to discharge effectively the duties of a flight mechanic. His problem, and his greatest deficiency, primarily, is the lack of first-hand knowledge of the equipment he is to operate, control and service. His training should be devoted mostly to remedying this lack and studying whatever applicable theory he missed while at college.

The practical man, provided his experience has been in the equipment he is to fly, is more prepared to assume flight mechanic duties at first, for he is familiar (at least in general) with the plane. Conversely, to the other man, his weak points will be a lack of the engineering approach as contrasted to the mechanic's approach and a need for theory. After absorbing the principles of flight operations for two or three years during which he by no means stops learning, the flight mechanic, whether a college or shop-trained man, will ordinarily be advanced to flight engineer and will be competent to assume the responsibilities of the job.

It may be noted here that PAA has found it profitable to develop its flight engineer training program to the dimensions of a full-fledged technical school in order to give its men this theoretical and practical background as well as to provide a convenient and economical means of familiarizing a rather large and growing group with the various types of aircraft operated.

It may be felt that background is being stressed unduly. The authors do not feel so. It appears to them that an individual after several years as flight engineer is more than adequately fitted for executive ground jobs where a well balanced background in all phases of airline maintenance is a requisite. Whether the ground job be in engineering or in the shops, flight training and experience is invaluable. In the future, it may even be considered an essential prerequisite to the executive position.

The traits which are the flight engineer's raw materials are: Ability to think analytically, ability to reduce circumstances to basic principles, and a "feeling" for mechanics and electricity. He must be fit physically and be able to act quickly and accurately in emergencies, and he is subject to rigid personal discipline in order to live amicably with his flight crew associates, for he will live and work in close cooperation with them for extended periods of time.

Book Reviews

(*Continued from page 229*)

SAFETY AFTER SOLO, by John R. Hoyt. McGraw-Hill Book Co., New York City. 336 pages, illustrations, index, $3.

Drawn from his Navy and CAA experience,